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PROGRESS REPORTS 1982 - 1983

FOREWORD

This publication contains brief technical reports on the projects supported by the Saskatchewan Agricultural Research Fund in the 1982-83 fiscal year. If the reader requires more detailed information on any of these projects the respective author should be contacted.

These reports reflect the work of the second year of the Saskatchewan Agricultural Research Fund Board. The Board extends its appreciation to the researchers involved and looks forward to the continuation of the high quality achieved thus far.

Information on the operation of the Fund can be obtained by writing to the Secretary, Saskatchewan Agricultural Research Fund Board, 3085 Albert Street, Regina, Saskatchewan, S4S 0B1.

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CEREAL CROPS

EFFECTS OF THE RATE AND DATE OF PRESEEDING FERTILIZER PLACEMENT AND POSTSEEDING PACKING REQUIREMENTS WHEN USING A PNEUMATIC SEEDER

L.A. McLean, L. Henry

ABSTRACT

Phosphorus fertilizer was applied at 4 rates and 3 dates at 3 locations with a fourth location initiated using 3 rates and 2 dates on a Weyburn soil. Preliminary yield data indicates a normal response to phosphorus levels with possibly small differences due to method of application. Packing was found to increase seed emergence, reduce grain moisture at maturity and increase wheat yield. This response was not as dramatic in 1982 as in the dry year of 1981.

BACKGROUND AND OBJECTIVES

Under semi-arid conditions (dark brown soils) to maintain uniform seeding emergence, ripening and adequate yields, packing behind seeding implements is a necessity. The air seeders currently being promoted for use as cultivator fertilizer applicators and seeding implements have little, if any, packing in the operation. In addition most of the manufacturing companies involved in promoting air seeders stress the advantages of placing P_2O_5 below the seed in a separate operation prior to seeding with the unit. Thus management systems to prevent drying of the soil and maintaining a seed bed are very important. This test was designed to evaluate the effects of time of fertilizer placement, rates of fertilizer applied and how these two factors relate to the important aspect of seed bed packing.

Farmers are currently requesting information on the air seeder and wondering if they can maintain yields with this implement. This study is proposed to answer some of their questions on when to apply fertilizer, what rates and what subsequent packing should be done. Since air seeders do appear to have some time packing factors e.g. seed fill, etc. the packing and fertilizer placement may give added advantages.

In order to obtain this information two separate experiments were established to evaluate the effect of these management objectives on yield and agronomic characters. The overall objectives were to determine the effect of:

(a) placing phosphate fertilizer below the depth of seeding at different dates (late fall, early spring and at seeding).
(b) placing phosphate fertilizer below the depth of seeding at different rates (0, 20, 40, 80 lbs. per acre P_2O_5).

(c) post seeding packing in conjunction with the above two treatments.

EXPERIMENTAL METHOD

As indicated two separate experiments were initiated.

Experiment #1 (P_2O_5 placement date and rate)

Two sites were initiated in the fall of 1980 (Sutherland clay, Bradwell fine sandy loam) and one set up for the fall of 1981 (Weyburn loam). The established sites are at the Kernen Crop Research Farm (stubble) and the Goodale Farm (fallow). The third site was selected on a Weyburn soil 11 miles east of Saskatoon. In addition a second site was established on the Bradwell soil type.

Three dates of P_2O_5 placement (a) fall (applied Oct. 16/81)
(b) spring (April 29/82)
(c) with seed (seeded May 7/82)

Rates: 0, 40, 80, 120 lbs. P_2O_5 per acre (except site on Weyburn Soil)

Checks: 40 lbs. P_2O_5 with discer
40 lbs. P_2O_5 with drill

These areas were seeded to Neepawa wheat on May 7th or 15th (heavy soil texture) with the air seeder, discer and drill. These areas had 80 kg/ha actual N applied on October 22/81. The plots were sprayed with a mixture of Hoegrass and Pardner and areas were harvested on August 30/82.

Experiment #2

Packing test after seeding with the pneumatic seeder
Stubble land (Kernen Farm, heavy clay soil)
Treatments; No preseed tillage - no packing
- one packing
- 2nd packing immediately after seeding
Preseed tillage - no packing
- one packing
- 2nd packing

These 6 treatments (each 160' x 240') were arranged in a randomized complete block design of 4 replications.

The plots were seeded May 13, 1982 to Neepawa wheat using the pneumatic seeder. The packing treatments were also done on May 13/82. The preseeding tillage was done using a deep tillage cultivator on May 11/82. The plots were sprayed with Avenge Pardner and were combined on August 28, 1982.

RESULTS AND DISCUSSION

The following data has been collected and tabulated (Tables 1-4). A general response in yield of approximatley 400 kg/ha was shown with the higher P_2O_5 levels as well as a slight advance of maturity. To obtain good results at least one more years data would be required.

Table 1. GOODALE P_2O_5 - 1982 (ESTABLISHED 1981)

		Emergence (Plants/m^2)	Seed Depth (cm)	Plant Heights (cm)	Maturity (% Moisture)	Yield (kg/ha)	Protein (%)
Fall	0	168	8	83	31	2492	14.5
	40	165	7	84	32	2639	14.4
	80	163	8	82	29	2706	14.6
	120	170	7	85	29	2853	14.8
Early Spring	0	188	9	81	34	2333	13.9
	40	142	9	87	36	2406	14.0
	80	181	8	83	27	2552	14.1
	120	160	9	86	32	2612	14.6
Spring with	0	186	5	84	29	2499	13.6
Seed	40	175	6	86	27	2659	14.0
	80	129	5	84	26	2542	14.5
	120	173	5	87	30	2750	13.9
Press Drill	40	176	5	83	20	2650	13.9
Discer	40	192	7	85	20	2774	13.7

Table 2. P_2O_5 GOODALE - 1982 (ESTABLISHED 1980)

		Emergence (Plants/m^2)	Seed Depth (cm)	Plant Heights (cm)	Maturity (% Moisture)	Yield (kg/ha)	Protein (%)
Fall	0	92	10	90	45	2340	15.9
	40	100	11	92	44	2750	15.7
	80	116	9	91	43	2820	16.5
	120	96	10	96	48	2988	16.3
Early Spring	0	92	11	94	47	2325	15.9
	40	176	9	89	39	3005	16.5
	80	112	10	92	45	3128	16.1
	120	164	9	92	41	3107	16.5
Spring with	0	172	7	83	36	3166	16.1
Seed	40	160	9	95	42	3240	16.7
	80	92	6	91	40	3083	16.1
	120	184	5	89	36	3381	16.5
Press Drill	40	180	6	79	32	3182	16.2
Discer	40	188	8	86	37	3222	16.7

Table 3. WEYBURN P_2O_5 - 1982 (ESTABLISHED 1981)

		Emergence (Plants/m^2)	Seed Depth (cm)	Plant Heights (cm)	Maturity (% Moisture)	Yield (kg/ha)	Protein (%)
Fall	0	140	8	74	40	2311	15.1
	60	136	9	76	41	2390	15.3
	120	108	9	78	41	2600	15.5
Spring with	0	104	8	83	41	2560	14.6
Seed	60	180	6	75	33	2628	14.5
	120	188	7	75	32	2632	14.9
Press Drill	60	200	5	75	27	2531	14.1

Table 4. 1982 - KERNEN PHOSPHATE (ESTABLISHED 1980)

Treatments		Yield (kg/ha)	Maturity (% Moisture on wet basis)	Plant Heights (cm)	Emergence Counts (Plants/m^2)	Seed Depth (cm)
Fall	0	2725	40	87	172	7
	40	2801	41	91	172	8
	80	2759	40	92	204	8
	120	2948	41	91	208	8
Spring	0	2628	42	91	204	8
	40	2791	41	92	176	9
	80	2869	41	92	204	8
	120	2327	42	88	188	7
Seed	0	2708	39	94	220	8
	40	2815	37	91	244	7
	80	3014	38	92	196	7
	120	2917	40	94	200	7
Drill	40	2692	38			
Discer	40	3002	38	92	192	8

Table 5. 1982 PACKING TEST

	# of Times Packed	Emergence (Plants/m^2)	Seed Depth (cm)	Plant Heights (cm)	Maturity (% Moisture)	Yield (kg/ha)	Protein (%)
No Tillage	0	156	8	96	42	3155	16.2
	1	164	7	95	40	3209	15.2
	2	180	7	93	40	3071	16.2
Preseeded	0	156	8	97	43	3162	15.5
Tillage	1	152	8	91	41	3028	16.5
	2	172	8	90	39	2981	15.8

IMPACT

This project has been terminated before adequate data could be gathered to determine the impact of various dates of incorporated P_2O_5 fertilizer with the air seeder. It does appear though that late fall applications with the air seeder are as good as other dates of application.

THE EVALUATION OF THE NITROGEN REQUIREMENTS FOR CEREAL GRAINS GROWN UNDER THE ZERO TILL FARMING SYSTEM

M.C.J. Grevers and D.A. Rennie

ABSTRACT

A fertilizer nitrogen placement study was initiated at 3 locations: at Drinkwater, winter wheat on a heavy clay; at Leipzig, spring wheat on a loam; and at Kindersley, barley (Z-till) and wheat (C-till) on a clay loam. The placements were fall broadcast, winter broadcast, spring broadcast, fall deep band, spring deep band, fall seed-place and spring seedplace. Fertilizer nitrogen rates were 67 and 134 kg N/ha. Crop yield and quality, moisture use, and fertilizer nitrogen uptake were measured along with other agronomic data.

For spring cereals grown under zero-till, spring deep band and spring seedplace were superior fertilizer nitrogen placement methods. Winter broadcast nitrogen was a good alternative where successful snow trapping had been achieved. Winter wheat grown under zero-till responded best to spring broadcast and fall deep band nitrogen. Under conventional tell yield increases due to fertilizer nitrogen were far less dramatic. Spring broadcast and fall deep band nitrogen were the more successful placement methods.

Percent fertilizer N recovery was also assessed using 15_N tracers. Data from this work indicate higher fertilizer N recovery under zero-till. Deep band nitrogen resulted in higher percent recovery than broadcast nitrogen under zero-till.

Soil physical properties affecting soil fertility were measured at 6 locations which had been under zero-till for a least 4 years. Differences between soils under zero-till and conventional till were quite small especially in the soils of heavy clay texture. Aggregates were found to be larger under zero-till while gaseous diffusion was also higher thus indicating a more continuous pore system under zero-till. Results on bulk densities and aeration porosities were inconsistent.

Percent carbon and percent polysaccharides of the aggregates showed no clear trend due to tillage treatment. The soil temperature regime during the growing season showed that at one site soil temperatures were on average of 3°C cooler under zero-till at 5 cm depth and 0.5-1.0°C cooler at 10 cm depth.

Soil Water Recharge Over Winter

The effectiveness of snow trapping in terms of increasing the soil water content was evaluated at two sites; at Leipzig on a Weyburn loam, and at Drinkwater on a Regina heavy clay. The soil moisture status in the fall and in the spring was measured by gravimetric analysis. The effect of snow fences (0.6 m high and 9 m apart) was also assessed on both the zero tilled field and the conventionally tilled field.

At Leipzig zero tilled fields trapped considerably more snow and subsequently gained more soil water from snow trapping than the conventional tilled fields, water contained in the trapped snow was 8.5 cm and 4.9 cm for the zero and conventional till, respectively. Under conventional tillage the soil profile actually lost water (2cm) which may be due to evaporation and drainage, whereas under zero tillage there was a net gain of close to 4 cm of soil moisture. The placement of snow fences on the fields improved snow trapping considerabley, the extra gain in soil moisture from fall to spring was 7.4 cm under zero tillage and 6.5 cm under conventional tillage.

At the Drinkwater site snow trapping proved to be less effective due to the initially high soil moisture content from high fall rains. In the fall the soil profiles under zero tillage were near saturation (94% - 98%) which reduced further soil water infiltration, while drainage caused soil water losses from the rooting zone. The soil profiles under conventional tillage were substantially dryer (77% -84% saturation) and were therefore able to effectively gain more water from the snow melt. Spring soil moisture contents were similar under both tillage systems at 51 cm of water or 91% saturation.

Fertilizer Placement Study

The placement of nitrogen fertilizer in the form of urea was tested on 3 soils; Regina HvC, Weyburn L and Kindersley CL. Spring cereals were seeded on the Weyburn and Kindersley soils while winter wheat was seeded on the Regina soil.

A. Winter Wheat on Regina HvC (5th ft Year Zero Till)

The yield of winter wheat under conventional tillage (C-T) averaged 40% higher than under zero tillage (Z-T) as shown in Table 1. Both fields had been in fallow the previous year. Soil fertility levels in the fall were similar for both fields at 90 kg of NO_3^--N per ha to a depth of 60 cm. Spring soil moisture levels to a depth of 120 cm were higher

under Z-T, 54.0 cm compared to 51.1 cm under C-T. The Z-T field was therefore near saturation (92%) which has a detrimental effect on soil aeration and thus crop growth and soil fertility in general. By the end of the growing season soil moisture contents were similar under both tillage treatments, 43.1 cm (73% saturation). The water use efficiency (W.U.E.) values for the crop were calculated by dividing the grain yield by the water from precipitation and that lost from the soil profile during the growing season. W.U.E. were significantly higher under C-T which would further indicate more optimum growing conditions for crops under C-T. This indication is supported by the fact that at harvest, soil NO_3^--N levels for the 0-60 cm depth were 28% higher under C-T than under Z-T.

Table 1. Yield of winter wheat on Regina HvC.

Fertilizer nitrogen placement	Rate of N applied	Yield	W.U.E.*	Yield	W.U.E.
	kg/ha	kg/ha	kg/ha/cm	kg/ha	kg/ha/cm
		Zero Tillage**		Conventional Tillage***	
Check		2518a,b	155	3580e	211
B - Fall	67	2951b,c,d	170	3911e	211
B - Fall	134	2997b,c,d	165	3996e	245
B - Winter	67	2341a	142	3972e	224
B - Winter	134	3034c,d	170	4083e	269
B - Spring	67	3251d	196	4233e	255
B - Spring	134	3090c,d	161	3921e	236
DB - Fall	67	3203d	159	4157e	272
DB - Fall	134	3020b,c,d	177	4120e	210
SP - Fall	67	2625a,b,c,	152	3496e	269
SP - Fall	134	2163a	143	3936e	237
Average		2787	162	3907	237

B - broadcast, DB - deep band, Sp - seed placed
* W.U.E. = water use efficiency; ** Zero-till = 1981 chem. fallow
*** Conventional till = 1981 summerfallow
a-e - Similar letters in vertical columns show values that are not statistically different.

Method of fertilizer placement was more critical to crop yield under Z-T than under C-T. Higher mineralization rates of soil organic matter under C-T resulted in more soil nitrogen becoming available for crop growth than would be the case under Z-T. Subsequently there would be a greater dependency on fertilizer placed nitrogen under Z-T. Largest yield increases under Z-T occurred with spring broadcast and fall deep band applications at the rate of 67 kg N/ha. Yield increases were 29% and 27%, respectively. Fall seed placed and winter (snow) broadcast N were among the poorest treatments. Under C-T yield increases were similar amongst the treatments except for the fall seed placed N which was considerably poorer.

Percent protein was slightly higher under C-T than under Z-T 11.2% and 10.3% respectively. Fertilizer N applications increased protein content by 0.9% under Z-T and 0.6% under C-T.

Apparent N recovery from fertilizer N was similar under both tillage treatments. Spring broadcast and fall deep banded N resulted in an average 39% and 33% fertilizer efficiency under Z-T and under C-T the efficiencies were 33% and 32%, respectively. Winter broadcast and fall seed placed N resulted in the lowest fertilizer efficiencies under both tillage systems. The higher rate of N fertilizer generally resulted in substantially lower fertilizer efficiencies; under Z-T the values were 25% and 16%, while under C-T the values were 20% and 13% for the 67 kg N/ha and 134 kg N/ha, respectively.

B. Spring Wheat on Weyburn L (4th Year Zero Till)

C-T spring wheat yields were higher by approximately 14% over Z-T spring wheat (Table 2). The C-T field (previously summerfallow) had a considerably higher level of soil fertility, 76 Kg/ha of NO_3^--N to a depth of 60 cm compared with 32 kg/ha for the Z-T field. At harvest soil NO_3^--N levels were 15.8 kg/ha and 28.7 kg/ha under Z-T and C-T, respectively. Subsequently the wheat crop growing under C-T was grown under significantly higher levels of soil fertility than those under Z-T. The higher soil fertility under C-T allowed the crop to make better use of soil moisture as is indicated by the higher water use efficiency values under C-T. Spring soil moisture levels were similar, 29 cm and 27 cm of H_2O under Z-T and C-T, respectively.

Table 2. Yields of spring wheat on Weyburn L.

Fertilizer nitrogen placement	Rate of N applied	Yield	W.U.E.	Yield	W.U.E.
	kg/ha	kg/ha	kg/ha/cm	kg/ha	kg/ha/cm
		Zero tillage*		Conventional tillage**	
Check		1859a	78	2410d	117
B - Fall	67	2514b,c	93	2745e	120
B - Winter	67	2657c	124	2699e	127
B - Spring	67	2368b	75	3233f	120
DB - Fall	67	2467b,c	77	2934e	117
DB - Spring	67	2667c	107	2753e	131
SP - Spring	67	2691c	87	2861e	121
Average		2460	92	2805	122

B- broadcast, DB - deep band, SP - seed placed
* Zero-till - stubble; ** Conventional till - summerfallow
a-f - Similar letters in vertical columns show values that are not statistically different.

Method of fertilizer N placement was far more critical under Z-T where yield increases averaged 32% compared with 16% under C-T. The optimum placement under Z-T was different than under C-T. The spring seed placed, spring deep banded and winter broadcast applications of fertilizer N resulted in the highest yield increase under Z-T; 45%, 44% and 43%, respectively. However, under C-T spring broadcast resulted in the highest yield increase, 34%. The success of the winter broadcast N application under Z-T may be due to the success of the snow trapping earlier eluded to for this site.

Percent protein was significantly higher under C-T 13.7% than under Z-T (11.4%). This phenomena can be attributed to the substantially higher soil NO_3^--N levels found in these fields.

Apparent N recovery from fertilizer N was found to be similar amongst the tillage treatments at 29%. Under Z-T the highest efficiencies were for spring seed placed, spring deep band and winter broadcast applied N at 30%, 33% and 36%, respectively. Under C-T spring seed place resulted in 40% efficiency and spring broadcast in 48% efficiency.

C. Spring Cereals on Kindersley CL (4th Year Zero Till)

At the Kindersley site the Z-T field was seeded to barley and C-T field was seeded to wheat. Weed problems in the Z-T field caused severe yield reductions whereas weed control was adequate under C-T. Spring soil moisture was significantly lower under Z-T (40 cm) than under C-T (46 cm). Soil fertility levels were higher under C-T (85 kg/ha of NO_3^--N) than under Z-T (55 kg/ha of NO_3^--N). At harvest these values were 57 and 32 kg/ha for the C-T and Z-T fields, respectively. The combined effect of poor weed control, lower soil moisture and lower soil fertility levels resulted in substantially lower grain yield under Z-T (Table 3). The water use efficiency was 30% higher under C-T which can be a direct effect of poor weed control under Z-T for this site.

Table 3. Yield of wheat and barley on Kindersley CL.

Fertilizer nitrogen placement	Rate of N applied	Barley yield	W.U.E.	Wheat yield	W.U.E.
	kg/ha	kg/ha	kg/ha/cm	kg/ha	kg/ha/cm
		Zero tillage*		Conventional tillage**	
Check		990a	57	2360g,h	108
B - Spring	67	1229a,b	77	2561h,i,j,	103
B - Spring	134	1468b,c	79	2608i,j	122
DB - Spring	0	1146a,b	61	2165g	107
DB - Spring	67	2002d,e	100	2413h,i	104
DB - Spring	134	2311e,f	111	2599i,j	114
SP - Spring	67	1805c,d	117	2483h,i,j	95
SP - Spring	134	2473f	115	2681j	115
Average		1678	83	2484	108

B - broadcast, DB - deep band, SP - seed placed
* Zero-till - stubble; ** Conventional till - summerfallow
a-j - Similar letters in vertical columns show values that are not statistically different.

Method of fertilizer placement under Z-T in many cases doubled the yields compared to the check yield, but resulted in only minor yield increases under C-T. This would further emphasize the theory that much of the plant available nitrogen pool under C-T orignates from the mineralization of soil organic matter, thereby making the plant less dependent on fertilizer N. Under Z-T, spring seed placed and deep banded N proved superior to spring braodcast N. The mechanical action of spring deep banding resulted in a small yield increase under Z-T, but in a yield decrease under C-T. It is possible that under Z-T the mechanical action of the deep banding implement improved soil aeration. Under C-T the deep banding action may have resulted in additional soil water loss through evaporation.

Percent protein was significantly higher under C-T (13.0%) than under Z-T (10.0%). Both fertilizer placement and rate of N applied increased the protein percentage. Deep banding without adding N fertilizer resulted in a slight decrease in protein percentage especially under C-T.

Apparent N recovery from fertilizer N was higher under Z-T than under C-T. Under Z-T deep band and seed placed N resulted in efficiences of 20-30%, whereas broadcast N resulted in efficiences around 12%. Under C-T all treatments resulted in similar efficiencies around 20%.

D. Spring Wheat on Glaslyn, Oxbow Loam (3rd Year Zero Till)

No fertilizer placement test had been started at this site due to time constraints, however yield and crop water use were monitored. Soil fertility levels were similar for Z-T and for C-T at the start of the growing season. Yields were 2703 kg/ha and 2313 kg/ha under C-T and Z-T, respectively. Water use efficiencies were higher under C-T (143 kg/ha/cm) than under Z-T (122 kg/ha/cm). Total N content in the harvested portion of the crop were 63 kg/ha and 50 kg/ha under C-T and Z-T, respectively.

E. Summary of Fertilizer Placement Studies

The study indicates that fertilizer N applications resulted in larger yield increases under Z-T than under C-T. The generally higher soil NO_3^--N levels found under C-T are likely due to higher rate of mineralization of soil organic matter. Crop growth under C-T is therefore less dependent on fertilizer placed nitrogen. The higher fertility levels also resulted in higher yields and protein content. Water use efficiencies were also higher with C-T.

The optimum methods of N placement were not the same amongst tillage experiments (Table 4). For spring cereals grown under Z-T, spring deep banded and spring seed placed N were effective fertilizer N placement methods. Winter broadcast N was a good alternative to either spring deep banding or seed placing only where snow trapping had resulted in substantial gains in soil moisture over winter. For the Z-T winter wheat crop spring broadcast and fall deep band applied were the better treatments, while fall seed placed and winter broadcast N were the poorer treatment.

Under C-T most fertilizer treatments resulted in similar yield increases except at Leipzig. The spring wheat grown in Leipzig responded well to spring broadcast and fall deep banded N, and only moderately to winter broadcast, spring deep banded and spring seed placed N.

Table 4. Efficiency of fertilizer nitrogen placement.

Fertilizer nitrogen placement	Rate of N applied	Apparent N recovery from fertilizer N	
	kg/ha	Z-T	C-T
Broadcast - Fall	67	25	23
Broadcast - Fall	134	17	15
Broadcast - Winter	67	19	22
Broadcast - Winter	134	17	15
Broadcast - Spring	67	23	37
Broadcast - Spring	134	18	15
Deep Band - Fall	67	30	33
Deep Band - Fall	134	19	15
Deep Band - Spring	67	26	29
Deep Band - Spring	134	32	25
Seed Placed - Fall	67	25	14
Seed Placed - Fall	134	6	16
Seed Placed - Spring	67	30	32
Seed Placed - Spring	134	27	16

F. Disposition of Fertilizer Nitrogen Using Tracer (^{15}N)

At the Leipzig site cylinders (15 cm x 30 cm) were installed where ^{15}N enriched urea was applied either as broadcast or deep band fertilizer. These "microplots" were harvested separately, crop and soil samples were taken for yield of dry matter, total N content and % ^{15}N recovery.

The efficiency of fertilizer uptake by the plant was substantially greater under zero tillage (Table 5). Under zero till deep band N resulted in 25% more N uptake than under conv. till. This data is supported by the results of the apparent N recovery which showed a similar pattern. Under conv. tillage deep band N resulted in 57% more N recovery than broadcast. The latter results were contradicted by those of the apparent N recovery data, thus suggesting errors or shortcomings in one of the two methods. One area of concern is the large amount of unaccounted for ^{15}N under conv. til - B.C. (49.8%) which is possible due to leaching or denitrification. From this data it can be concluded that there was no consistant difference between deep band and broadcast N under conv. till.

Table 5. Percent fertilizer N recovery using ^{15}N.

Sample	Zero till		Conventional till	
	Broadcast	Deep Band	Broadcast	Deep Band
	%			
Grain	45.3	55.3	27.8*	44.1
Straw	11.9	16.0	7.1*	10.8
G + S	57.2	71.3	34.9*	54.9
Soil	19.8	6.8	15.3*	24.7
Unaccounted for	23.0	21.9	49.8*	20.4

* Value is suspect, analysis is being repeated

In summary, the tracer data indicate that the percentage fertilizer nitrogen recovery was substantially greater under zero till. Deep band proved superior to broadcast N under zero tillage but was not different under conv. tillage.

The work using ^{15}N was not conclusive and points into the direction of further trials. During 1983 a more intensive program will be initiated where ^{15}N labelled fertilizer will be seed-placed, deep banded and broadcast applied.

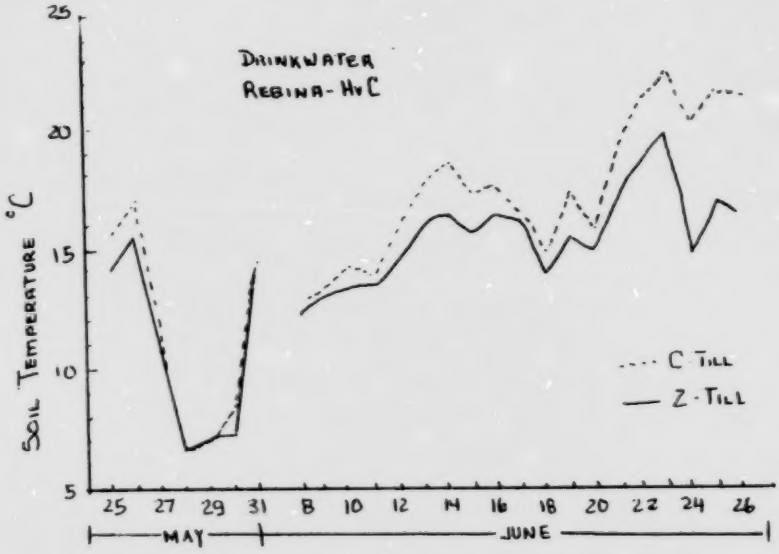
Soil Temperature Regime During The Growing Season

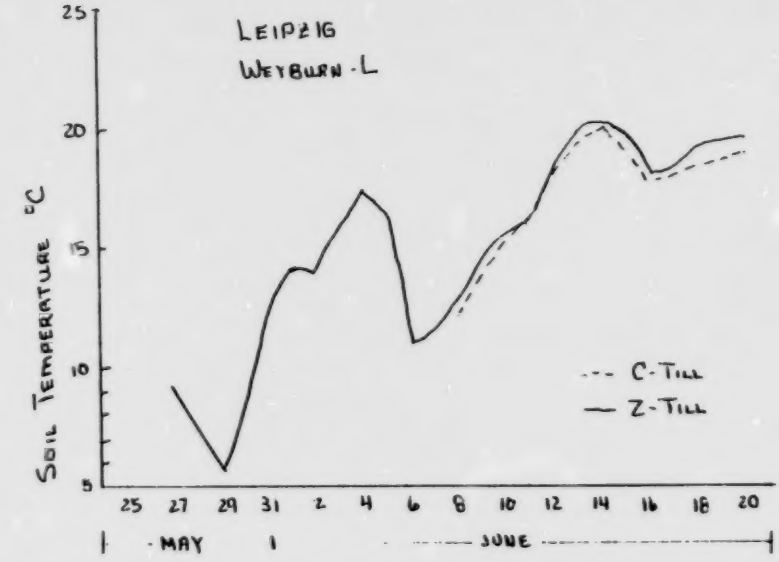
Under zero tillage conditions surface residues can reflect considerable amounts of incoming shortwave solar radiation and can also result in an insulating effect in terms of soil warming from long wave radiation. Soil temperature regimes during the first weeks of the growing season have a marked effect on both early crop growth and soil fertility. It was with the above in mind that soil temperatures were monitored at two sites: Drinkwater (Regina HvC) and Leipzig (Weyburn L). Thermisters were installed at 5, 10 and 50 cm depths, while the data were stored in microloggers (Campbell Scientific Inc. units CR 5 and CR 21).

The soil temperature regimes at 5 cm depth for the first 4 weeks of the experiment are shown in Figure 1. Soil temperatures were an average of 3°C warmer under conv. till than under zero till at the Drinkwater site. This difference in temperature was reduced to 0.5 to 1.0°C at the 10 cm depth, while at the 50 cm depth temperatures were similar.

At Leipzig the soil temperatures at 5 cm tended to be slightly warmer under zero till. Malfunctioning of the recording unit resulted in the soil temperatures under conv. till were not recorded from May 27th until June 8th. It was this period in time which was crucial for determining the effect of tillage on soil temperatures since as the growing season

advances the plant canopy will also have a substantial effect on soil temperature. The soil temperature at Leipzig trend can therefore be explained by the fact that in the particular locations where the thermisters were placed there was substantially thicker plant canopy under conv. till (6837 kg/ha dry matter at harvest) than under zero till (4814 kg/ha dry matter). There were no differences between conv. till and zero till at the 10 and 50 cm depths.





In summary, the tests indicate that at least in one site soil temperatures were considerably cooler under zero till. The cooler

temperatures could have adversely affected early crop growth and processes such as nitrification. Cooler spring soil temperatures could possibly have been one of the factors which caused lower crop yields under zero till at Drinkwater.

The Effect of Zero Tillage on Soil Structure

Many farmers express concern that under zero tillage their soil may become "hard" due to the lack of mechancial soil disturbance. Research carried out in the U.S. and Europe have indicated that soil structure deterioration may indeed occur under zero till. Vehicular traffic over the soil can result in soil compaction depending on the weight of the units and the soil moisture content. Under Saskatchewan conditions soil moisture levels are usually well below that which is considered "optimum" for soil compaction.

In order to determine the impact of zero tillage on soil structure under Saskatchewan conditions, fields at 6 locations were sampled where zeo till had been practiced for at least 4 years. The samples were analyzed for bulk density, air filled pore space, hydraulic conductivity aggregate size distribution and soil strength.

Soil bulk densities under conventional till were either greater than or equal to those found under zero till. Similar results were determined with air filled porosities where at two of the sites values were significantly higher under conventional till. Hydraulic conductivity values were only significantly different at one site where they were higher under zero till. Measurements of soil strength were carried out using a penetrometer and a shear vane. There were no differences between tillage treatments at a depth of 5 cm. At the 10 cm depth soils under conv. till appeared to have greater strength than those under zero till. Differences in bulk density, air filled pore space, hydraulic conductivity and soil strength occurred under clay loam soils while heavy clay soils appeared unaffected. Soils of higher clay content are more subjected to self churning due to cycles of freezing and thawing and wetting and drying, and therefore may have a natural mechanism to counteract compaction.

The size distribution of soil aggregates was measured using a rotary sieve. The results indicate significantly larger aggregates under zero till in the A horizon, whereas in the B horizon no consistent pattern was apparent. There was no effect of clay content as was the case with soil bulk density, etc. Subsequently larger aggregate formation may be attributed to soil organic matter and microbial activity rather than clay bonding. The soil aggregates from the A horizon were analyzed for percent carbon and percent polysaccharides. There was no clear trend in either % C or % polysaccharides due to tillage treatment.
Soil aeration was assessed on soil samples in the field and in the lab (He) using a flow meter. The rate of gaseous diffusion into the soil was

substantially faster under zero till. The result therefore indicate a more continuous pore system under zero tillage.

In summary, there were some differences in soil structure between soils under zero till and under conv. till. Heavy clay soils appear to be the least affected by the absence of tillage. Larger soil aggregates and improved soil aeration were the case under zero tillage. In general the quality of soil structure of zero till soils was either similar to or better than the structure of conv. till soils.

THE INHERITANCE AND NATURE OF SPROUTING RESISTANCE IN BARLEY

B.L. Harvey, B.G. Rossnagel and R.P. Muderewich

ABSTRACT

A source of dormancy WM143-2-3b, was generously made available to us by Dr. D.R. Metcalfe. We crossed WM143-2-3b with Norbert, Fairfield and S77433. Norbert is highly susceptible to sprouting, Fairfield has a small amount of dormancy and S77433 is hulless and non dormant.

The following tentative conclusions have been drawn from the preliminary observations we have made to date. The dormancy factor(s) appears to be located in the hulls. The inheritance of dormancy is quantitative and of medium heritability. It should be possible to select segregants with adequate levels of sprouting resistance. It will be difficult, however, to select sprouting resistant types with good malting quality since there is a positive relationship between sprouting susceptibility and amylolytic enzyme activity.

BACKGROUND AND OBJECTIVES

Klages barley and several of its derivatives are very prone to pre-harvest sprouting which is known to drastically reduce the quality of malting barley. Normally, harvest conditions in the traditional two row area of western Canada do not favor sprouting even in susceptible varieties. However, in some years and some locations wet harvest weather does occur. Thus the potential for serious problems does exist. Furthermore, the popularity of Klages with the malting and brewing industry has led to the cultivation of this variety in cooler, moister areas where the probability of poor harvest conditions is much greater.

The basic difference between Klages and older malting varieties, such as Betzes, is a much higher level of amylolytic enzyme activity. This leads one to suspect that there is a relationship between sprouting and amylolytic activity. This suspicion is supported by the fact that Domen,

the donor of high enzyme activity to Klages, is also highly susceptible to sprouting. If this is correct, it leads to the question, can a suitable source of dormancy be found which can be combined with high amylolytic activity?

EXPERIMENTAL METHOD

Wpg M143-2-3b a dormant line obtained from Dr. D.R. Metcalfe was crossed to Norbert (susceptible), Fairfield (intermediate) and S77433 (hulless). Spaced planted F_2's and F_3 head rows were grown in the field. Approximately 300 plants were harvested at random from the F_2 generation of each of the three crosses. Individual plants were also harvested from each of the four parents. In the F_3 generation 10 plants were harvested individually from each row and the remainder of the row was bulk harvested. Seed was threshed immediately and stored at -19°C until germination tests were conducted.
A portion of the seed of the WM143-2-3b/Norbert cross was stored at +18°C for eight months and then micromalted and analyzed for a-amylase activity and diastatic power.

The analysis of the F_2 data of the S77433/WM143-2-3b cross revealed that germination of all hulless segregates was high whereas the germination of hulled segregates varied from 0 to 95%. Therefore several experiments were conducted to investigate the role of the hull in sprouting resistance. Seed of WM143-2-3b was punctured through the lemma and palea using a dissecting needle and then germination tested. Seeds of WM143-2-3b were dehulled by hand and then germinated. Seeds of Norbert were germinated in the same petri dish as seeds of WM143-2-3b in the ratios of 1:4, 1:9 and 1:19. Hulls of WM143-2-3b, and S77431 (a sister line of S77433) were collected and used to produce aqueous extracts. These extracts were then tested to determine their effects on germination of the four parents.

RESULTS AND DISCUSSION

Germination in each of the F_2 populations varied from 0 to 100% and the germination of the parents in each case were WM143-2-3b 15%, Norbert 90%; WM143-2-3b 24%, Fairfield 49%; WM143-2-3b 18%, S77433 83%. (Figs. 1, 2 and 3). The germination of F_3 segregates and parents was much higher than in the previous year. This undoubtedly reduced the heritability.

Heritability was calculated from the regression of F_2 and F_3 data for the crosses WM143-2-3b/Norbert and Fairfield/WM143-2-3b. The heritabilities were 23.2% and 23.0% respectively.

The storage period of eight months was sufficient for the dormancy to disappear from the WM143-2-3b/Norbert cross thus germination was high in all of the F_2 plants which were micromalted. The correlations between germination (at harvest) and a-amylase and diastatic power of the malted grain were $r = 0.485^{**}$ and $r = 0.32^{**}$ respectively. While these findings

indicate that there is a negative relationship between sprouting resistance and amylolytic activity it should be possible to select genotypes which combine sprouting resistance with high amylolytic activity. We have selected F_5 lines from this cross which appear to combine these features. Dr. D.R. Metcalfe (personal communication) has also obtained such lines from a cross involving Maris Concorde and Klages derivatives from his breeding program.

As indicated above, all of the hulless segregates from the F_2 of the cross S77433/WM143-2-3b had high germination, whereas the hulled segregates varied from 0% to 95%. Thus the dormancy factor appears to reside in the hulls. Germination of the hand-dehulled seed of WM143-2-3b supports this observation. The germination of the dehulled seed was 100% as compared with 5% for hulled controls from the same lot.

Seed of WM143-2-3b which was punctured with a dissecting needle had a lower germination than control seeds from the same lot (45.5% and 58.3% respectively). Thus the effect of the hulls on dormancy is apparently not a physical effect.

Germination of Norbert seed was not affected by the presence of WM143-2-3b seed in any of the ratios attempted. However, germination was inhibited in the presence of an aqueous extract (10 gms hulls/100 ml water) of hulls of WM143-2-3b. The germination of the Norbert control was 99% and the Norbert treated 19%. The germination of the four parents was also reduced by aqueous extracts of S77431 hulls (Table 1). It is not clear why the hulless parent was less affected than the three hulled parents. Thus there appears to be water soluble constituents in the hulls which are capable of germination inhibition. Further work is required to identify these constituents and their mode of action.

IMPACT

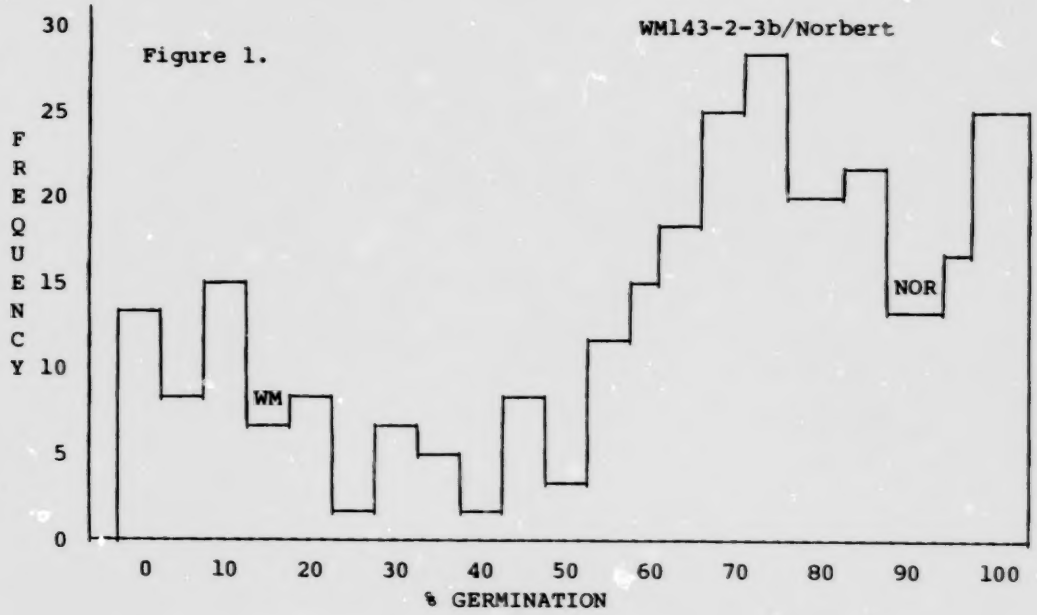
The introduction of the new, high quality, two-row malting barley varieties with high enzyme levels and rapid germination has increased sprouting losses in areas subject to wet harvest conditions. Transferring an acceptable level of post-harvest dormancy from exotic sources to locally adapted genotypes will aid in minimizing these losses. This will be of major importance to Saskatchewan barley producers.

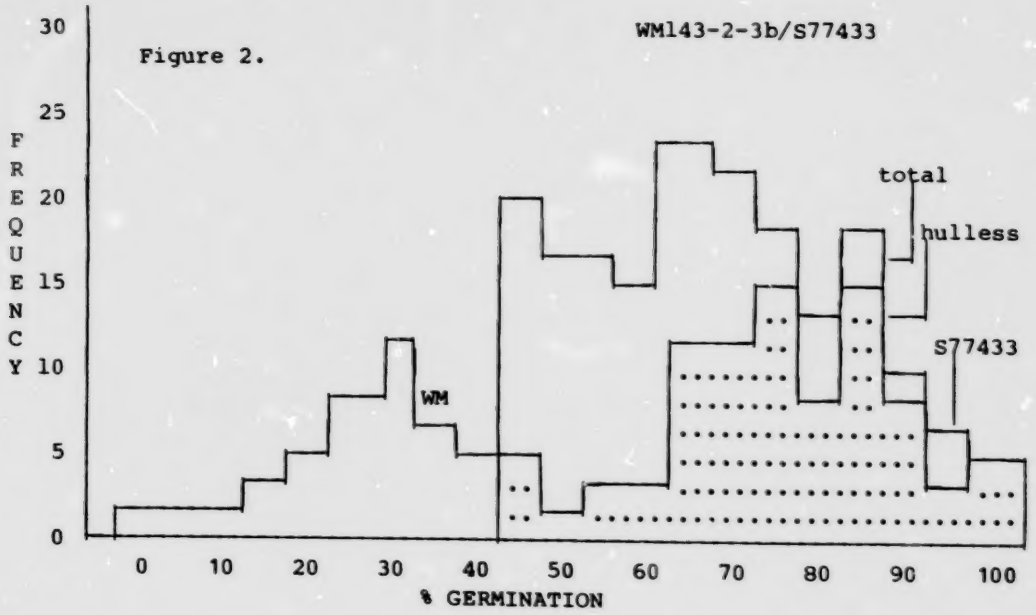
Table 1. The effects of aqueous hull extracts of S77431 on the germination of the four parents

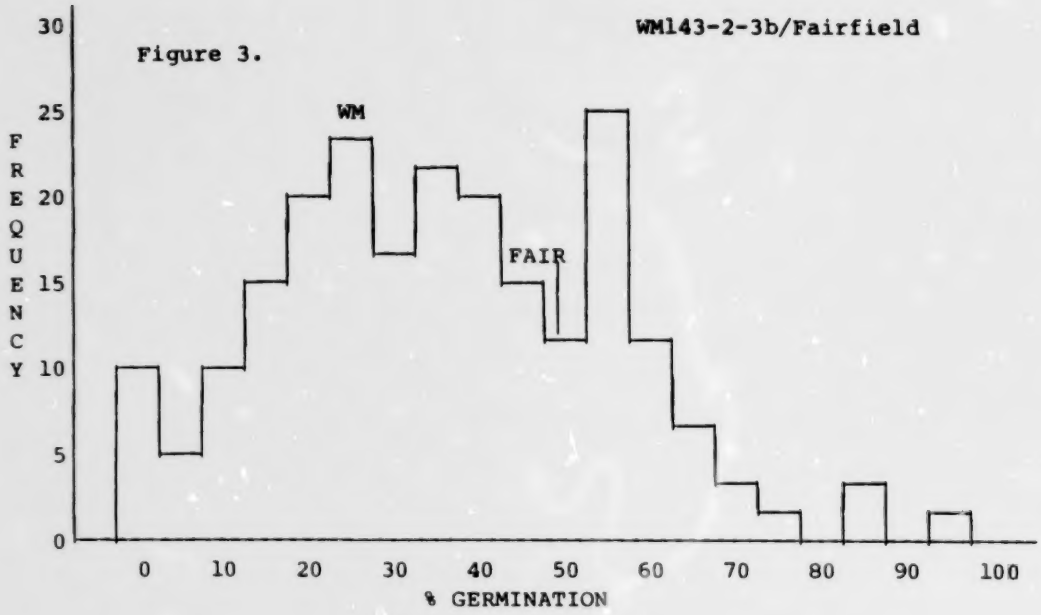
	Concentrations of extract			
	Control	5 g/100 ml	10 g/100 ml	20 g/100 ml
WM143-2-3b	78	39	53	25
Norbert	98	83	78	49
Fairfield	100	67	67	32
S77433	94	89	86	82

All values are significantly different from the control in the same row.

Figures 1,2 & 3 - Germination of Seed from F2 Plants







FROST TOLERANCE AND SUPERCOOLING IN ECONOMIC CROPS

L.V. Gusta

ABSTRACT

The formation of ice plants at sub-zero temperatures is due to the presence of ice nucleators. The most efficient nucleator for ice formation is ice itself although certain bacteria growing on leaves are very effective. The frost tolerance of cultivars of wheat, barley, oats, rape and mustard was determined at different stages of growth. The ability of plants to supercool or avoid frosts was determined in the presence and absence of ice nucleating bacteria. In order of frost tolerance, mustard and canola are the least tolerant species tested. The cotyledon stage of canola and mustard is the most sensitive stage of growth to frosts. The true leaves are approximately 1°C more frost tolerant than the cotyledons.

Leaves of wheat, barley and oats not infected with ice nucleating bacteria readily supercool or avoid frosts to temperatures as low as -9° to -10°C. Plant infected with ice nucleating bacteria freeze at approximately -4° to -5°C, but can tolerate temperatures as low as -6° to -8°C without visible signs of damage. Of the three species, oats appear to be the most frost sensitive. The effect of various levels of frosts at different stages of development on yield, date of maturity, height, seed weight and germination is still being investigated.

BACKGROUND AND OBJECTIVES

Last year in western Canada over 1 billion dollars was lost in crop production due to an untimely frost at the end of August. Each year millions of dollars are lost in western Canada due to unseasonal frosts either in the spring or early fall.

Recently it has been established that if no ice nucleators are present water in plants will not freeze but remains in a liquid or supercooled state. If water does not freeze the plants avoid frosts and suffer no damage. Certain bacteria growing on leaves have been shown to be very effective ice nucleators.

The objectives of this research project are: 1) to determine the role of ice nucleating bacteria in promoting freezing in economic crops, e.g. wheat, barley, oats, canola and mustard. 2) To determine what temperature wheat, oats, barley, canola and mustard are killed at. 3) To determine what effect freezing temperatures in the spring and fall have on maturity, yield, plant height and growth of cereal, canola and mustard crops.

EXPERIMENTAL METHODS

Plants for the experiments were either grown in the field, in pots outside or in controlled environment chambers. Plants grown in controlled environment chambers were considered to be either bacteria free or to have a very low population of bacteria. Ice nucleating bacteria were obtained from Dr. S. Lindow and cultured in two medias. Each experiment was replicated either two or three times. In each test plants were subjected to controlled freeze.

RESULTS AND DISCUSSION

Cereal Frost Tests

Leaf Freezing Test

The leaves of six varieties of wheat, barley and oats were excised from plants growing in the field on June 3, June 17 and July 28. One-half of the leaves were allowed to supercool. The leaves were placed in a freezer held at -3°C overnight and then cooled at 2°C/h to -5°, -6°, -7°, -8°, -10°, -12° and -14°c. At each temperature leaves were rated for viability.

Table 1. Freeze killing Temperature (°C) of Excised Cereal Leaves Collected from the Field.

Species	Supercooled			Inoculated		
Cultivar	June 3	June 17	July 28	June 3	June 17	July 28
Wheat						
Leader	-10			-8		
Benito	-10.5			-9		
Columbus	-11.5	-9	- 9	-9	-6.5	-7
Glenlea	-11	-7	-10	-7.5	-6	-7
Neepawa	-10	-9	-10	-8	-6.5	-7
Sinton	-11			-8		
Barley						
Fairfield	- 9.5			-8.5		
Harrington	- 9	-7	-10	-8.5	-5	-8
Summit	-11			-9.5		
Bonanza	-10	-7	-10	-9	-6	-8
Melvin	-10.5	-7	-10	-8.5	-6.5	-8
Klondike	-10.5			-9		
Oats						
Cascade	- 9	-8	-10	-7.5	-5	-7.5
Dumont	- 9	-8	- 4	-7.5	-5	-4
Harmon	- 9.5	-9	- 4	-7.5	-6.5	-4
OT307	-10			-7		
OT308	-10			-8		
Random	-11			-8		

As shown in Table 1 excised leaves did not freeze until -9° to -11°C if they were not sprayed with ice nucleating bacteria (INB). Leaves which supercooled escaped freezing injury because no ice formed in their tissue. Leaves which were sprayed with INB froze at -3°C. However, these leaves could tolerate a frost of -7° to -9°C depending upon the cultivar and species. As a rule, in the early spring collection leaves from wheat, barley and oats could survive a frost of -7° to -9°C.

The barley varieties were similar to the wheat varieties in frost hardiness. The frost tolerance of oat leaves was somewhat less than that of the wheat and barley varieties. Initially oat leaves could tolerate a frost of -7° to -9°C, however by July 28, Dumont and Harmon were killed at -4°C. It appears that Cascade may be several degrees more frost tolerant than Dumont and Harmon.

The leaves from the wheat, barley and oat varieties were washed in phosphate buffer to determine their bacterial populations and also the ability of the bacteria to initiate ice formation. These results are now being tabulated and analyzed and will be available in 1983.

Whole Plant Freeze Tests

Three experiments were conducted on whole plants in pots outside.

1. At the 3 to 4 leaf stage whole plants were frozen to -4°, -6°, -8° and -10°C to determine what effect a frost had on survival, maturity, yield, plant height, tiller number, and grain quality. Although all of the results are not in yet several general comments can be made. Plants not sprayed with INB could survive a colder frost than those sprayed with INB. Plants sprayed with INB could tolerate a frost of -6° to -8°C. Frosts (-4°C and lower) affected plant height and tiller number for many varieties.

Six cultivars of wheat at the 4 to 5 leaf stage were subjected to -3°, -6° and -9°C for one hour. One half of the population were sprayed with ice nucleating bacteria and the other half were sprayed with water. Plants sprayed with ice nucleating bacteria froze at -3°C while the control plants in most cases supercooled. A frost at -3°C resulted in taller plants, slightly higher yield and more seeds/head (Table 2). Plants frozen at -6° and -9°C were delayed in maturity compared to the control.

Table 2. The Effect of Sub-zero Temperatures on Several Agronomic Characters of Six Common Spring Wheats

Temperature	Plant Height (cm)	Yield (gm)	Seeds/ head	Seed Wt. (gm)	Heads/ plant
-3 (-)	74	4.9	14.5	0.0318	2.2
-3 (+)	82	5.7	18.5	0.0319	2.2
-6 (-)	75	4.3	14.0	0.0325	2.0
-6 (+)	70	3.4	13.0	0.0304	1.6
-9 (-)	70	3.3	14.3	0.0317	2.0
-9 (+)	70	3.4	14.8	0.0330	1.8

Values in parenthesis indicate if plants were (+) or were not (-) sprayed with ice nucleating bacteria.

Six cultivars, Benito, Columbus, Glenlea, Leader, Neepawa, Sinton.

Plants planted outside May 3 and subjected to sub-zero temperatures at the 4 to 5 leaf stage on June 4.

2. At the early dough stage (56% seed moisture) wheat, barley and oat plants were subjected to -4°, -6°, and -8°C. One half of the plants were sprayed with ice nucleating bacteria and the other half with water.

Results are reported for six cultivars of wheat. The barley and oat data have not been analyzed to date. Plants subjected to -6°C and -8°C were lower in yield, had less seeds per head and lighter seed weight than the control plants.

Table 3. The Effect of Sub-zero Temperatures On Certain Agronomic Characters of Six Bread Wheats at 56% Seed Moisture Content

Temperature	Seed Number	Yield (gm)	Seeds/ Head	Seed Weight (gm)
Control	197	5.5	17.5	0.0268
-4 (-)	184	5.37	17.5	0.0285
-4 (+)	179	5.12	16.2	0.0290
-6 (-)	146	2.65	14.25	0.0179
-6 (+)	129	2.39	12.25	0.0192
-8 (-)	156	3.07	14.0	0.0198
-8 (+)	150	2.98	15.5	0.0184

Values in parenthesis indicate if the plants were (+) or were not (-) sprayed with ice nucleating bacteria.

3. At the late dough stage wheat, barey and oat plants were subjected to -4°, -6°, -8°C to determine what effect there was on seed yield, quality, germination and protein content. The data on barley and oats have not been analyzed to date. The effect of sub-zero temperatures on yield, seeds per head and seed weight of six cultivars of wheat at the 24% seed moisture stage is summarized in Table 4. The yield of grain and the number of seeds per head from plants exposed to sub-zero temperatures was slightly reduced, however seed weight was not affected.

Table 4. The Effect of Sub-zero Temperatures on Certain Agronomic Characters of Six Bread Wheats at 24% Moisture

Temperature	Yield (gm)	Seeds/ Head	Seed Weight (gm)
Control	5.49	17.5	0.0268
-4 (-)	4.09	15.25	0.0270
-4 (+)	4.32	16.0	0.0270
-6 (-)	5.37	16.75	0.0273
-6 (+)	5.09	16.0	0.0276
-8 (-)	4.84	14.75	0.0268
-8 (+)	4.34	14.50	0.0296

Values in parenthesis indicate if the plants were (+) or were not (-) sprayed with ice nucleating bacteria.

Leaves collected on August 10 and washed in phosphate buffer had high populations of ice nucleating bacteria. Bacteria collected from wheat were not effective until -6°C whereas bacteria collected from oats and barley were effective in causing freezing at -3° to -4°C.

Rape and Mustard Frost Test

The rape varieties Tobin, Midas, Westar, Bronowski, Torch and Altex and the mustard varieties Domo and Gisilba were grown in a growth chamber with 15°C day and 5°C dark. At the 1 to 3 leaf stage and at the 4 to 6 leaf stage one half of the population was sprayed with ice nucleating bacteria and the other half with distilled water. The plants were cooled to -4°, -6° and -7°C and then rated for survival and injury. The surviving plants were grown to maturity. Many of the varieties sprayed with ice nucleating bacteria were killed or injured at -6° to -7°C.

The effect of sub-zero temperatures on the 1 to 3 leaf stage and the 4 to 6 leaf stage on days to heading, days to flowering and plant height is summarized in Tables 5 and 6. Plants sprayed with ice nucleating bacteria and subjected to -4°C or lower were delayed in days to heading and days to flowering. Plants at the 1 to 3 leaf stage were more sensitive to -4°C as compared to plants at the 4 to 6 leaf stage.

Results of the yield data will be available at the end of 1983.

Rape and mustard plants grown in growth chambers at 15°C day and 5°C dark were exposed to sub-zero temperatures at different stages of development (Table 6). Plants at the cotyledon stage were the most frost sensitve. The variety Torch was the most frost resistant being able to tolerate -5°C.

The cotyledons of all other cultivars were killed at -4°C. Although the cotyledons were killed at -4°C, certain cultivars namely Ortho and Gisilba were still able to produce true leaves. The rape cultivars Westar and Altex frozen at -4°C produced true leaves but were not as vigorous as Ortho and Gisilba.

It appears that the Argentine rapes and some of the mustards were able to grow faster at 10°C day, 5°C dark than the Polish cultivars.

Rape and mustard cultivars in the 3 to 6 leaf stage can readily tolerate -5° to -6°C. However, most cultivars suffer extensive injury at -8°C. Plants sprayed with ice nucleating bacteria freeze at a warmer temperature than the control plants. There does not apear to be very much frost tolerance in rape cultivars. Plants grown in the greenhouse at

Table 5. The Effect of Sub-zero Temperatures on heading, flowering and plant height of rape and mustard plants at the 1 to 3 leaf stage.

Temp. (°C)	Altex			Bronowski			Domo			Gisilba			Midas			Tobin			Torch			Westar		
	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T
Control	56	64	34	81	92	67	47	53	35	46	52	47	64	74	41	45	50	33	48	55	38	62	71	43
-4 (-)	59	66	40	78	96	81	53	59	42	53	58	41	74	83	53	50	52	35	45	54	36	61	69	47
-4 (+)	76	78	52	87	98	80	60	66	50	49	56	40	70	73	41	54	64	41	60	73	38	69	85	58
-5 (-)	70	78	42	88	89	53	63	65	50	54	65	48	71	76	40	52	62	27	57	63	35	70	76	52
-5 (+)	71	84	61	93	97	73	65	77	49	57	73	40	87	74	50	61	73	36	-	-	-	76	82	54
-6 (-)	69	77	47	-	-	-	57	64	38	55	60	28	76	79	59	52	56	29	55	67	52	61	70	51
-6 (+)	77	89	54	80	97	84	61	70	52	50	57	35	73	84	49	55	61	31	58	63	35	67	77	62

Values in parenthesis indicate if plants were (+) or were not (-) sprayed with ice nucleating bacteria.

Table 6. The Effect of Sub-zero Temperatures on Heading, Flowering and Plant Height of Rape and Mustard Plants

Temp. (°C)	Altex			Domo			Gisilba			Midas			Tobin			Torch			Westar		
	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T	H	F	T
Control	46	54	50	42	48	50	38	44	42	54	62	44	39	43	32	42	47	35	47	56	47
-4 (-)	44	54	40	41	47	36	37	42	36	55	63	42	41	50	32	42	47	46	48	56	49
-4 (+)	47	54	41	42	48	36	38	46	32	53	61	40	39	44	27	42	46	29	47	54	40
-5 (-)	54	63	47	49	53	35	43	52	36	71	82	26	43	52	33	44	50	34	51	62	43
-5 (+)	53	57	36	45	50	27	47	58	32	60	69	39	48	56	34	45	54	43	56	66	40
-6 (-)	47	57	41	49	57	35	43	18	37	58	65	41	43	52	37	44	49	32	62	66	35
-6 (+)	56	66	51	50	57	47	53	64	42	56	65	40	45	54	33	43	47	30	63	72	34

Plants subjected to sub-zero temperatures when 33 days old (4 to 6 leaf stage). Values in parenthesis indicate if plants were (+) or were not (-) sprayed with ice nucleating bacteria.

H = days to heading
F = days to flowering
T = plant height in cm

Table 7. Frost Tolerance of Rape and Mustard Plants at Different Stages of Development.

Temperature (°C)		-4°C					5°C					-6°C			
Plant age (days)		14-16	21-22	21-22	32-34		14-16	21-22	21-22	32-34		14-16	21-22	21-22	32-34
Leaf Stage	Cot*	1-3	1-3†	3-5	4-6	Cot*	1-3	1-3†	3-5	4-6	Cot*	1-3	1-3†	3-5	4-6
Altex (-)		4.8	0.5	4.1	4.9		3.8	0.8	4.0	3.5		1.1	3.3.	2.8	2.0
(+)	2.3	2.5	2.5	4.0	3.9	0	0.8	0	3.7	3.1	0	0.8	0.5	2.2	4.0
Bronowski (-)		4.8					1.8					0.3			
(+)		4.0					0.7					0.3			
Domo (-)		4.3	1.0	3.3	4.4		3.4	0.5	2.8	2.0		3.4	4.0	2.6	3.8
(+)	1.0	3.8	0.8	1.7	4.4	1.0	2.1	1.1	3.8	3.0	0	0.8		1.0	2.5
Gisilba (-)		4.8	0	2.0	4.8		0.3	1.0	4.7	2.6		3.4	2.5	3.8	1.8
(+)	1.0	4.3	1.5	2.8	2.0	0.5	2.3	0.5	2.3	1.8	0	1.5	0.5	2.5	1.4
Midas (-)		3.3			4.5		3.9			2.1		0.8			3.9
(+)	0.9	2.5			5.0	0.4	0.9			3.0	0	0.5			4.5
Ochre (-)			1.5	1.2				1.0	4.8				1.5	3.8	
(+)	1.4		2.5	2.0		0.4		0	4.5		0		0	2.5	
Sabre (-)			0.5	1.0				1.0	2.0				1.5	4.2	
(+)	1.0		0	0.5		0.4		0	2.9		0		0	1.3	
Tobin (-)		4.3	1.0	2.8	4.5		3.6	0	3.7	4.5		2.3	2.5	2.3	3.8
(+)	1.0	1.8	0.5	3.3	4.5		2.6	0.5	3.3	2.5		1.3	1.0	1.8	3.3
Torch (-)		3.3	1.0	3.0	4.8		1.9	0	3.3	3.0		1.2	2.5	3.5	3.5
(+)	3.7	3.8	0	2.3	4.8	3.5	0	0	3.5	2.8	0	0.7	0.5	2.5	4.1
Westar(-)		4.5	0.5	1.0	4.6		1.5	0.5	3.0	3.8		1.2	1.5	2.2	2.3
(+)	1.4	3.0	1.8	1.8	4.4	0.7	0.8	0	3.0	3.3	0	0.5	1.0	1.5	2.0

Plants grown at 15°C day and 5°C dark with a 15 h photoperiod.
† = plants grown in greenhouse at approximately 20°C day and 15°C dark.
Values in parenthesis indicate if plants were (+) or were not (-) sprayed with ice nucleating bacteria.
Plants were rated for freezing injury 3 days after the freeze test by four people independently.
5 = no damage 0 = dead
Cot* = cotyledon stage

approximately 20°C (Table 6) were more frost sensitive than plants at the same leaf stage grown at 15°C day and 5°C dark. It appears that rape and mustard plants have some ability to cold harden at lower temperatures.

Rape and mustard plants at full bloom and at partial seed size were subjected to sub-zero temperatures to determine what effect there was on seed yield and quality. The result of this experiment should be available late in 1983.

SPECIAL CROPS

IMPROVED MANAGEMENT PRACTICES FOR CANARYSEED PRODUCTION

A.E. Slinkard and B.N. Drew

ABSTRACT

Results from on-farm trials indicate that canaryseed yields increased as seeding rate increased up to about 60 kg/ha in 1982 (a wet year) in contrast to lack of a yield increase at seeding rates above 22 kg/ha in 1981 (a dry year). Thus, a seeding rate of 30-35 kg/ha is a good compromise. The yields of Alden and Keet were comparable. Stubble-seeded canaryseed yielded 84% of comparable fallow-seeded canaryseed in 1982 (a wet year) in contrast to only 51% in 1981 (a dry year). On average, canaryseed is less drought tolerant than wheat. Good responses to N and P_2O_5 fertilizer were obtained in 1982 (a wet year) in contrast to the lack of response in 1981 (a dry year). Seed yield was markedly reduced by seeding too deep ($\geq$8 cm) or by not using Avadex BW in a field that was heavily infested with wild oats. Difenzoquat (AVENGE) and flamprop methyl (MATAVEN) were registered for wild oat control in canaryseed. A large number of other herbicides were found acceptable for weed control in canaryseed and attempts will be made to get some of them registered for use in canaryseed production.

BACKGROUND AND OBJECTIVES

Canaryseed is widely used as food for caged and wild birds and is a major component of bird food mixtures. Canaryseed production was initiated in Manitoba in 1957 and subsequently become centered in Saskatchewan. Production of canaryseed in Saskatchewan has increased to over 25,000 ha in 1980 and 1981 and 48,000 ha in 1982, largely through the promotional efforts of various grain companies. Canaryseed is well adapted to Saskatchewan and the crop has prospered in the absence of any research data on the effects of various management practices on seed yield. Accordingly, the objectives of this research project are to develop improved management practices for canaryseed production and to demonstrate the value of these practices under conditions of commercial production.

EXPERIMENTAL METHOD

The majority of these studies were conducted in commercial canaryseed fields. Cooperating farmers were asked to establish one or two strips of a contrasting management practice in their fields. Subsequently, a series of 6 to 12 paired plots were established in these strips and the adjacent field and data collected on stand density, weed control and seed yield. Data from these paired plots were then analyzed statistically.

RESULTS AND DISCUSSION

1. Seeding rate studies

Three seeding rate studies were conducted in 1982 and the results are summarized in Table 1. On both the Brynes and Krenz plots seed yield increased from seeding rates above 30 kg/ha, possibly at rates approaching 60 kg/ha. However, on the University plots, seed yield levelled off at seeding rates above 29 kg/ha. These results suggest that the seeding rate should be around 30-35 kg/ha.

These results contrast sharply with those from 1981 (a dry year) when seed yield failed to increase seeding rates above 20 kg/ha. The primary reason for this is that 1982 was a wet year and the denser stands were able to develop and produce a higher seed yield. Thus a seeding rate of 30-35 kg/ha is suggested as the optimum.

Table 1. Effect of seeding rate on seed yield of canaryseed, 1982.

Cooperator	Seeding rate kg/ha	Stand counts plants/ft^2	Seed yield kg/ha
Brynes	30	37	1258
	60	56	1452
Krenz	17	21	1624
	34	43	1846
	68	78	2205
University (ALDEN)†	12	8	946
	17	11	1092
	23	15	1182
	29	17	1223
	34	20	1204
University (KEET)†	12	8	918
	17	11	1013
	23	15	1202
	29	17	1296
	34	20	1293

†Only about 50% emergence

2. Phosphate fertilization studies

A phosphate fertilization study was conducted on one farm. An application of 40 lb/ac of 11-51-0 with the seed increased seed yield by 10% (109 kg/ha). These results contrast to the lack of any response in 1981, a dry year.

3. Nitrogen fertilization studies

Nitrogen fertilization studies were conducted on two farms and the results are summarized in Table 2.

In the Agra field with a soil nitrogen test level of 52 kg/ha, there was a marked response to the first 25 kg/ha of added nitrogen, but only a minimal response to additional nitrogen. In the Fielding plots with a soil nitrogen test level of 123 kg/ha, there was no response to additional nitrogen. These results differ from the 1981 results when there was no response to added nitrogen since moisture was the limiting factor. These results also emphasize the importance of having a soil test on various fields as a guide to fertilizer application.

Table 2. Effect of nitrogen fertilization on seed yield of canaryseed, 1982

Cooperator	N soil test kg/ha	N rate kg/ha	Seed yield kg/ha
Agra	52	0	836
		25	1212
		50	1282
Fielding	123	0	1952
		19	1922
		38	2012

4. Variety comparison studies

Results of a variety x seeding rate study at Saskatoon indicate little difference in the yielding ability of Alden (1129 kg/ha) and Keet (1144 kg/ha).

5. Depth of seeding studies

A depth of seeding study was conducted and the results are summarized in Table 3. There was no difference in seed yield between the shallow (2.5 cm) seeding depth and the normal (5.0 cm) seeding depth. However, the deep (8.0 cm) seeding depth resulted in severe (23%) reduction in seed yield; the stand was much thinner and later maturing also. Thus, canaryseed should not be seeded 8 cm deep unless it is absolutely essential to make sure the seed is planted into moist soil.

Table 3. Effect of seeding depth on seed yield of canaryseed, 1982

Seeding depth (cm)	Seed yield (kg/ha)
2.5	1349
5.0	1362
8.0	1099

6. Stubble vs. fallow seeding studies

Paired comparisons of stubble vs. fallow seeding were conducted on three fields and the results are summarized in Table 4. Stubble seeding produced an average of 84% of fallow seeding in 1982 (a wet year) in contrast to only 51% in 1981 (a dry year). However, the two year average (68%) is still less than the comparable figure for wheat (70-80%), indicating that canaryseed is less drought tolerant than wheat.

Table 4. Effect of stubble vs. fallow seeding on seed yield of canaryseed, 1982

Cooperator	Seed yield under		Stubble yield as % of fallow yield
	Stubble	Fallow	
	-----kg/ha-----		
Krenz	1839	1878	98
Agra A	1127	1512	75
Agra B	1199	1552	77
Average	1388	1647	84

7. Wild oat control studies

The application of one quart/ac of Avedex BW in a canaryseed field heavil infested with wild oats increased seed yield from 948 kg/ha to 1842 kg/ha These results emphasize the poor competitive ability of canaryseed and reiterate the importance of good weed control practices in canaryseed production.

8. Herbicide tolerance studies

Postemergence broadleaf weed control products bromoxynil and MCPA ester alone and as a commercial or tank mixture, bentazon, dicamba, DOWCO 290, 2,4-D amine, MCPA amine and MCPB produced acceptable canaryseed tolerance Post-emergence wild oat control products flamprop methyl, difenzoquat and barban did not injure the canaryseed crop. Postemergence propanil alone or in a commercial mixture with MCPA provided marginally acceptable tolerance with a high level of vegetative recovery reflected by seed yields equivalent to the untreated control. Tank-mixtures of flamprop methyl and difenzoquat with MCPA and bromozynil did not injure the canaryseed. Preplant soil incorporated triallate did not produce any detrimental effects on the canaryseed.

Treatments other than those listed above produced unacceptable levels of crop tolerance.

IMPACT

The area devoted to canaryseed production increased from about 25,00 ha in 1980 and 1981 to over 48,000 ha in 1982. The development of information on improved agronomic practices under this project and the extension of this information to the canaryseed producer has helped make this increased production possible. Thus, this project has helped complete registration of difenzoquat (AVENGE 200C) and flamprop methyl (MATAVEN) for wild oat control. A major program of field scale testing with propanil (STAMPEDE) and propanil plus MCPA (STAMPEDE CM) was undertaken as a means of moving these products toward full registration status.

An extension bulletin, Canaryseed Production in Saskatchewan, was published in early 1982. Researchers were active in field days and specialty crop seminars and used phone and mail communications to assist canaryseed producers with their crop management problems. All of these efforts helped Saskatchewan produce a record canaryseed crop in 1982.

RAPESEED MEAL AND RAPESEED BY-PRODUCT EVALUATION AND UTILIZATION

J.M. Bell

ABSTRACT

A feeding trial involving 144 crossbred pigs was conducted to determine when and under what conditions canola meal can most effectively be introduced into the feeding program for market pigs. Canola meal was fed commencing at 23, 34 or 45 kg pig weights, replacing soybean meal. The meal was fed with and without supplementary lysine. The basal grain used was barley compared with barley:wheat fed in a 2:1 ratio, in order to assess the effects of dietary energy level when canola meal was used. The main results of the first replicate of 72 pigs are reported. The inclusion of wheat did not improve the growth or feed utilization of the pigs. The addition of lysine to diets containing canola meal improved growth rate and efficiency of feed utilization during the first half of the growing period. However, those pigs that were not fed supplemental lysine during early life had largely overcome their earlier nutritional disadvantages by the time they weighed 68 kg and showed no effects of early deficiency of lysine during their finishing phase (68-102 kg). There appeared to be a slight acceptance (palatability) problem with canola meal whenever first introduced. Lysine supplementation of canola meal allowed efficiency of feed utilization to equal that obtained on soybean meal diets. Good quality barley provided ample digestible energy intakes to complement canola meal and to permit normal growth and good efficiency of feed utilization.

BACKGROUND AND OBJECTIVES

Experimental results pertaining to the use of canola meal in the diets of weanling and starter pigs have shown certain inconsistencies and the development of appropriate recommendations for practical use of the meal has been difficult. Canola meal is clearly superior to its predecessor rapeseed meal but questions of digestible energy level, palatability, protein quality and residual glucosinolate level arise in regard to using the meal for young pigs.

Young pigs, compared to older ones, have relatively high protein and amino acid requirements. They respond more adversely to low energy, high fibre diets. Their thyroid activity is high and more susceptible to the effects of anti-thyroid factors such as glucosinolates.

EXPERIMENTAL METHOD

This experiment was designed to address all of the above-mentioned factors. A total of 144 individually fed crossbred pigs were used in a feeding trial covering the weight range of 23 to 102 kg (50 to 220 lb). This report contains the main results of the first replicate of 72 pigs, consequently the results and conclusions are strictly tentative.

Comparisons were made between diets containing barley and barley:wheat (2:1) grain mixtures in the basal diets supplemented with canola meal, in order to test the meal at two levels of digestible energy. Canola meal was introduced into the diet at different pig weights (23, 34 and 45 kg) to determine nutritional and palatability effects. In addition the effects of lysine supplementation commencing at 23 kg and terminating at 34 or 45 kg was assessed. The first replicate, here reported, involved relatively high crude protein levels in the cereal grains, consequently the needs for and responses to supplementary protein and lysine would be lower than the needs with lower protein grain.

RESULTS AND DISCUSSION

The inclusion of wheat to provide one-third of the basal grain in the diet as a means of increasing the digestible energy content of the diet, had relatively little, if any, effect on pig performance (Table 1). In fact, the pigs fed barley showed marginally greater daily feed intakes and daily gains than those fed barley + wheat diets. The efficiency of feed utilization was not improved by the inclusion of wheat.

These findings regarding wheat confirm previous finding in this laboratory (Anderson and Bell, 1983) in which several cultivars of wheat, despite its higher digestible energy and protein contents, generally failed to excel barley in pig diets. It was postulated that the amino acids threonine and isoleucine may have been growth limiting factors associated with wheat. However, data on these aspects of the current experiment remain to be examined.

Supplementation of canola meal diets with lysine, the first limiting amino acid in canola meal, barley and most wheat varieties, yielded beneficial results (Table 2). In the 23 to 34 kg stage of growth, lysine supplementation improved growth rate by 6% and efficiency of feed conversion by 7%. The efficiency of feed conversion was superior to that of pigs fed the soybean meal diets but pigs fed the canola meal diets, with or without lysine supplementation, ate less feed than those fed soybean meal. This suggests that the lysine-supplemented canola meal diets were nutritionally superior to but less palatable than the soybean meal diets for young pigs. This confirms previous work.

When a longer growth phase, 23 to 45 kg, was considered, it appeared that canola meal was being accepted as readily as soybean meal. Lysine continued to improve daily gains and efficiency of feed conversion but gains were significantly lower than for those pigs fed soybean meal. This may have been due in part to continuing marginally (3%) lower daily feed intakes of pigs fed lysine-supplemented canola meal.

Considering the total growth period from 23 to 68 kg, the benefits of earlier supplementary lysine had largely disappeared. There was no improvement in daily gain and the improvement in efficiency of feed utilization, while statistically significant, was only 3%. Part of this finding may be associated with the trend of lower feed intakes for the lysine-supplemented pigs. This unexpected result may be resolved upon completion of the second replicate of this experiment. Nevertheless these results from an experiment in which relatively high protein basal grains were used indicate that lysine supplementation may improve canola meal when fed to pigs up to 34 or 45 kg weight but the lysine deficiency may be sufficiently marginal that the pigs are able to compensate for the early deficiency as they grow older and into a changing amino acid requirement phase when dietary lysine requirements fall.

The performance of the pigs during the finishing period (68 to 102 kg) (Table 3) showed that those pigs fed canola meal throughout the 23 to 102 kg period grained about 3% more slowly (not significant statistically) and consumed about the same amount of daily feed as those fed soybean meal. Efficiency of feed utilization was similar for the two diets. Adjustments of the daily gains, to remove statistically the within-group variations in feed intakes, resulted in equal gains for the two groups. These results indicate that the deficiency of lysine in canola during the early growth period, which marginally affected daily gains and significantly affected efficiency of feed conversion, did not carry over into the finishing period. As mentioned above, such effects had largely disappeared in the 45 to 68 kg weight phase.

Lysine supplementation up to 34 or 45 kg resulted in no significant improvement in performance during the 68 to 102 kg finishing period (Table 3). This confirms the previous observation that the benefit from supplementation with lysine occurs in the early growth stage when lysine requirement levels are higher.

Pigs started on a soybean meal diet and switched to canola meal at 34 kg performed equally well as those fed soybean throughout the 23-102 kg weight range. The poorer results obtained when the switch was made at 45 kg were unexpected and may be explained when the second replicate results are complete.

Among those groups fed barley as the only basal grain, there was no evidence that lysine supplementation during early life had any significant effect on performance during the finishing period, thereby confirming the results obtained with the barley-wheat basals.

IMPACT

This project is providing better information with which to determine diet formulations for post-weaning pigs, with particular reference to the use of soybean meal as compared to canola meal and the need for lysine supplementation.

Table 1. Effects of barley:wheat (2:1) compared with barley basal grains in canola meal-supplemented diets on the performance of growing pigs from 23 kg initial weight to 34, 45 and 68 kg final weights.

Performance criteria	Basal grain in diet†	
	Barley:wheat (2:1)	Barley
Response, 23 to 34 kg		
Daily gain, g	569	588
Daily feed, kg	1.50	1.50
Feed/gain ratio	2.65	2.56
Response, 23 to 45 kg		
Daily gain, g	644	653
Daily feed, kg	1.76	1.77
Feed/gain ratio	2.75	2.72
Response, 23 to 68 kg		
Daily gain, g	717	728
Daily feed, kg	2.11	2.14
Feed/gain ratio	2.94	2.95

† No differences between responses to basal grains were significant ($P = 0.05$).

Table 2. Effects of lysine supplementation of canola meal diets on performance of growing pigs from 23 kg initial weight to 34, 45 and 68 kg final weights.

Performance criteria	Protein and amino acid supplement: Canola meal	Canola meal + lysine†	Soybean meal††
Response, 23 to 34 kg			
Daily gain, g	556[b]†††	590[a]	615[a]
Daily feed, kg	1.53[b]	1.48[b]	1.60[a]
Feed/gain ratio	2.76[c]	2.52[a]	2.64[b]
Response, 23 to 45 kg			
Daily gain, g	628[c]	659[b]	693[a]
Daily feed, kg	1.80	1.75	1.80
Feed/gain ratio	2.89[b]	2.66[a]	2.71[a]
Response, 23 to 68 kg			
Daily gain, g	728[b]	720[b]	762[a]
Daily feed, kg	2.19	2.09	2.20
Feed/gain ratio	3.01[b]	2.91[a]	2.91[a]

† One half of these pigs received no supplemental lysine after reaching 34 kg weight.

†† One third of these pigs received canola meal instead of soybean after reaching 34 kg weight.

††† Means within rows bearing different superscripts are significantly different ($P<0.05$).

Table 3. Performance of finishing pigs (68 to 102 kg) in relation to protein and lysine supplementation received during the growing period (23 to 68 kg).

Diet and Weight Sequence	Daily gain g	Daily feed intake kg	Feed/gain ratio	Adjusted† daily gain g
Barley-wheat basal				
Soybean meal, 23-102 kg	912[a]	3.26	3.60	877[ab]
Canola meal, 23-102 kg	884[ab]	3.15	3.60	878[ab]
Canola meal, 23-102 kg + lysine to 45 kg	909[a]	3.14	3.51	907[a]
Canola meal, 23-102 kg + lysine to 34 kg	835[ab]	2.94	3.52	885[ab]
Soybean meal to 34 kg canola meal 34-102 kg	908[a]	3.22	3.59	883[ab]
Soybean meal to 45 kg canola meal to 102 kg	802[b]	3.10	3.88	811[b]

con't

Diet and Weight Sequence	Daily gain g	Daily feed intake kg	Feed/gain ratio	Adjusted† daily gain g
Barley basal				
Canola meal, 23-102 kg	888[ab]	3.16	3.58	876[ab]
Canola meal, 23-102 kg + lysine to 34 kg	804[b]	3.10	3.88	814[b]
Canola meal, 23-102 kg +lysine to 45 kg	809[b]	3.06	3.83	829[ab]

† Adjusted by regression methods to eliminate effects of within-group differences in feed intakes.
†† Means followed the same letter are not statistically different.

BIOLOGY AND CONTROL OF ASCOCHYTA BLIGHT OF LENTILS

R.A.A. Morrall

ABSTRACT

Most experiments in 1982 were designed to confirm previous results, but the abnormal weather conditions during the growing season severely hampered progress with field aspects of the project. The two underlying problems were failure of plants to mature and consequenty extremely low yields, plus very severe disease pressure which probably tended to mask the effects of treatments on seed quality. Laird lentils again proved to be consistently more resistant than Eston or Commercial, and it was shown that the best time to measure disease levels for comparative purposes and yield prediction is in mid-season, not just before harvest as has traditionally been done. Desiccants applied before harvest may help to reduce ascochyta development on seed in the swath, but further work is necessary to confirm this. Soil temperature and, hence, seeding date affects the frequency of transmission of ascochyta from seed to seedling. However, although all experiments have shown consistent trends of increased transmission with lower temperatures, results have been erratic and frequency of transmission sometimes extremely low. Future work will include an in-depth study of the efficacy and cost-benefit ratios of foliar application of fungicides to control disease in mid-season.

BACKGROUND AND OBJECTIVES

The lentil industry has expanded considerably in recent years in western Canada but a major problem in production has been ascochyta blight, a disease caused by Ascochyta lentis that affects yield and seed quality.

The climatic conditions in 1982 resulted in some of the worst epidemics of ascochyta blight in commercial fields since the disease was first reported in 1978. Unfortunately, the same conditions caused serious problems in field plots. The general goal of the project is to increase understanding of the environmental factors and management practices that affect epidemics and consequently to develop better control practices. Several of the experiments that were planned for 1982 were designed to consolidate and confirm results obtained previously; however, the problems referred to above curtailed the amount of data that were obtained.

EXPERIMENTAL METHOD

Cultivar Reaction and Yield Losses

Data obtained from replicated yield loss trials in the field in 1980 and 81 (see 1981-82 progress report) were subjected to further statistical analysis to determine the regression relationship of yield on disease intensity. These results were prepared for publication (1).

Co-operative and other trials in different locations were visited in late August 1982 and assessed for disease intensity. This was part of an ongoing program to monitor disease reaction of new lentil breeding material.

Seed discoloration and Harvest Conditions

Plots were established in May 1982 at Laird, Saskatchewan to attempt to confirm previous work showing that swathing date, length of time in the swath and weather conditions correlate with seed quality as well as percentage seed infection and yield. The treatments, arranged factorially, were: two cultivars, Commercial and Laird; swathed at normal date and 10 days late; and harvested on the swathing date vs. 10 days later vs. 20 days later. Plots were inoculated artifically to encourage disease development. After harvest seed from each plot was rated for quality on a scale of 0-4 (Canada seed grades) and some samples were tested for percentage ascochyta infection by an agar plate test. Others remain to be tested.

Fungicides and Desiccants to Control Seed Discoloration

Previous studies of seed quality suggested that the preharvest application of fungicides or the use of a desiccant might reduce the amount of seed deterioration that normally occurs in the swath. Accordingly, experiments were set up in a farmer's feld of Commercial lentils in mid August 1982. It had originally been intended to study these factors in plots of two lentil cultivars that had been seeded using small plot machinery. However, problems with weather and emergence forced an alteration of the experimental design.

In the experiment on preharvest application of fungicides, the following ten compounds were initially screened in the lab for their ability to inhibit spore germination at 1, 10 and 100 ppm: Bravo, Difolatan, Rovral, Cyprex, Polyram, Bayleton, Benlate, Ronilan, Maneb and Manzate. Bravo, Difolatan and Cyprex were thus selected for field testing. Each of the three chemicals were then sprayed on 45 m^2 blocks of heavily infected lentils and another 45 m^2 was used as a non-sprayed check. One day later the plants in all four blocks were cut and divided into 6 piles of equal weight. Each pile was spread out on a 1 m^2 area of the ground in a 6-replicate completely randomized design to simulate swaths. Eleven days later the swaths were harvested and seed quality and percentage ascochyta infection were determined by the usual methods.

In the experiment on desiccants a 10-replicate randomized block design was used. Each plot was $9m^2$ and there were two treatments: - 1. Reglone sprayed at the equivalent of 1.4 litres product per hectare. 2. Untreated control, in which the plants were cut on the same day as Reglone application in the other treatment and placed in swaths. After 10 days the swaths were picked up, and the Reglone treated plots cut and picked up. All plants were forced -air dried and combined, then seed quality and percentage ascochyta infection were determined by the usual methods.

Transmission of Disease from Seed to Seedling

Two attempts were made to confirm previously reported results which suggested that successful transmission of disease from ascochyta-infected seed to emergent seedlings is affected by soil temperature. In the spring of 1982 a field experiment was performed at Saskatoon in which 35% ascochyta-infected lentil seed was planted in 6-row plots on 3 different dates to obtain different soil temperature values. Each treatment was replicated six times. The numbers of seedlings with ascochyta lesions were counted at 14 and 21 days after emergence and percentage transmission of disease was determined.

In the laboratory an experiment was performed in which infected seed was planted in pots and allowed to germinate and emerge in growth chambers held at 8, 12, 16 or 20°C. Two moisture regimens were also established, soil held constantly at near field capacity by daily watering and a drier regimen in which the pots were watered every other day. Forty replicate pots of each treatment were used. Once the seedlings began to emerge the pots were transferred to a greenhouse and infected seedlings were scored 20 days later. Percentage transmission was then calculated.

RESULTS AND DISCUSSION

Cultivar Reaction and Yield Losses

Based on 1980 and 1981 experiments it was shown that regression equations of the type

$$\text{Yield} = a + b\log_{10} \text{Disease Intensity}$$

generally gave significant fits to the data and fairly high R_2 values. The best fits were obtained when disease intensity was measured as percentage leaf area infected at mid-season or as "area under the disease progress curve" for the whole season. Using data from both years and for Laird, Commercial and Eston lentils the equation

Yield (g per m^2) = 220 + (-103 $\log_{10}$ % leaf area affected at mid season)

was derived by regression. From this the following yield loss equation was derived:

% Yield loss = 47 ($\log_{10}$ % leaf area affected at mid season)

The fact that in this analysis leaf area infected at mid-seasons proved to be a better predictor of yield than leaf area infected in late season probably reflects the fact that heavy disease causes premature leaflet abscission and may result in underestimation of disease intensity. This is of considerable future practical significance for disease surveys, assessment of disease reaction of new breeding material and testing the efficacy of fungicides to control disease. When time permits only a single assessment of disease during the season, it will be more useful to do this in mid-season than just before harvest, as has traditionally been the case.

In assessments of disease reaction of new breeding material in 1982, the cultivar Laird again showed substantially more resistance to ascochyta blight than Commercial and Eston lentils (Table 1). This experience was also borne out dramatically in growers' fields during the 1982 epidemic. Several other breeding lines showed resistance in 1982 equal to that to Laird; the level in Laird should be a minimum standard for any new cultivars licensed in the future.

Seed Discoloration and Harvest Conditions

Poor emergence and plant development due to snow and a cutworm infestation led to an enforced reduction in mid-season of the amount of replication planned. In addition cool moist weather in July and early frost led to most of the plants never maturing and setting seed. Consequently yields were vanishingly small and were not measured. Barely enough seed was salvaged to assess quality and this was uniformly low. In all treatments the seed graded Canada sample grade (more than 10% discolored or damaged). The results of an agar plate test for ascochyta on seed from a single replicate are shown in Table 2. It was anticipated that no differences between treatments would exist because of the uniformly low seed quality. However, this preliminary test on one replicate indicates major differences; the only conclusion that may be drawn so far is that it will be essential to test seed from the remaining four replicates.

Fungicides and Desiccants to Control Seed Discoloration

All seed from all treatments in both the preharvest fungicide and desiccant trials graded Canada sample grade. A manual count of samples of seed from the fungicide trial showed over 70% discolored in all treatments (Table 3). There were no significant differences between the check and the three fungicides in percentage ascochyta infection of the seed. In the desiccant trial the percentage infection of seed with ascochyta was much higher than in the fungicide trial but there was a small nonsignificant reduction ($p=0.20$) in the desiccant treatment compared with the swathed treatment. Few conclusions may be drawn from these results; it seems likely that the extremely heavy disease pressure caused by the severe epidemic in the commercial field may have masked any effects the treatments may have had. For this reason it is no doubt worthwhile to repeat the work, especially on desiccants, under conditions of more normal initial infestation of the crop. It is noteworthy that an increasing number of lentil growers are using desiccants anyway as part of their normal crop husbandry.

Transmission of Disease from Seed to Seedling

Different experiments have shown considerable variation in the percentage successful transmission of ascocyta from seed to seedling (Table 4). The frequency of transmission is often extremely low. However, in all cases there is a general and significant trend of increased transmission with lower soil temperatures. This confirms the increased danger of early seeding when infected seed must be used by a grower. The low frequency of transmission that may occur is gratifying for lentil growers. However, it must be realized that even one infected seedling in a thousand probably represents thousands of infected seedlings uniformly distributed in a field. If weather is favorable for disease spread during the summer, these still represent a major epidemiological hazard. Thus, the importance of using clean disease-free seed and reducing the frequency of transmission of disease from seed to seedling should not be overlooked.

IMPACT

Understanding the methods of transmission of plant diseases and the environmental factors which affect epidemics is essential in developing control stategies. Currently recommendations for the control of ascochyta blight of lentils consist of crop rotation, seed testing, the use of high quality seed and planting the cultivar Laird. Laird should provide a baseline for disease resistance in licensing new lentil cultivars, but it will be important to assess the disease reactions of potential new cultivars at the most appropriate stage of crop development, i.e. in mid-season. Our experience suggests that more may be possible in the manipulation of harvest practices to reduce seed quality losses in the swath, at least when disease pressure is not

extreme. The severe epidemics in both plots and commercial fields in 1982 emphasize the explosive potential of ascochyta blight when weather conditions are favourable. This suggests that a prime need of growers is an economical control measure that can be applied to crops in mid-season to reduce the severity of an epidemic after other control strategies have broken down. To these ends considerable emphasis in future work will be placed on foliar application of fungicides and use of desiccants.

References and Publications Arising from Work

1. Gossen B.D. and R.A.A. Morrall. Effect of ascochyta blight on seed yield and quality of lentils (manuscript submitted to Can. J. Pl. Path.)

2. Morrall R.A.A. 1983. Chapter on diseases of pulse crops for "Diseases of field crops in Canada." (in press)

3. Morrall R.A.A. and B.D. Gossen. 1983. Ascochyta blight of lentils. Proc. Pulse Crop Growers Conference, January 11, 1983, Saskatoon, Saskatchewan. (in press).

Table 1

Mean Ascochyta blight ratings of three lentil cultivars in plots expressed as a percentage of Commercial (Common Chilean) over a four-year period.*

	Commercial	Eston	Laird
1979 (1 location)	100%	100%	62%
1980 (2 locations)	100%	110%	67%
1981 (2 locations)	100%	96%	76%
1982 (1 location)	100%	100%	66%

*Rating taken at end-of-season. Values calculated as a percentage of Commercial in each year separately.

Table 2

Percentage ascochyta infection of seed of a single replicate in relation to seeding and harvest dates in 1982.

Cultivar	Seeding and Swathing Date*	Harvest Date** 1	2	3
Commercial	Early	9	9	17
Commercial	Late	19	34	48
Laird	Early	40	92	61
Laird	Late	35	66	63

* Commercial Early = 30/8/82; Commercial Late and Laird Early = 7/8/82; Laird Late = 15/8/82.

** Date 1 = Date of swathing; Date 2 = ca 8 days after swathing; Date 3 = ca 18 days after swathing.

Table 3

Percentage discoloration and percentage ascochyta infection of lentil seed from preharvest fungicide and desiccant trials in 1982.

Trial	Treatment	% seeds discolored	% ascochyta infection of seed
Preharvest fungicide	Check	72	25
	Cyprex	74	19
	Bravo	72	19
	Difolatan	71	23
Desiccant	Reglone treated	n.t.*	62**
	Swathed	n.t.	71**

* n.t. = not tested.

** Difference between these 2 figures signifcantly different at $p=0.2$ according to one-tailed t test.

Table 4

Combined results of growth chamber and field experiments on frequency of transmission of ascochyta blight from seed to seedling.

Time and nature of experiment	Treatments	Mean Percentage frequency of transmission*
1981 (Spring)** Growth chamber	8°C	62.0a***
	12°C	38.0b
	16°C	39.0b
	20°C	10.0c
1981 (Fall)** Field	Early seeding (relatively high soil temperatures)	1.6****
	Late seeding (relatively low soil temperatures)	4.5****
1982 (Spring) Field	Early seeding (relatively low soil temperatures)	6.5a***
	Mid seeding (intermediate soil temperatures)	5.6b
	Late seeding (relatively high soil temperatures)	2.2b
1982-83 (Winter) Growth chamber*****	8°C Dry regimen	7.0
	8°C Moist regimen	3.0
	12°C Dry regimen	3.3
	12°C Moist regimen	2.8
	16°C Dry regimen	2.7
	16°C Moist regimen	2.0
	20°C Dry regimen	4.3
	20°C Moist regimen	1.5

*Calculated as: $\frac{\text{\% diseased seedlings}}{\text{\% infected seed}} \times 100$

**See 1981-82 progress report

***Within an experiment means followed by the same letter not significantly different at p=0.05 according to Duncan's multiple range test.

****Significantly different from each other at p=0.05 according to a one-tailed t test.

*****No statistical analysis possible until this experiment has been repeated due to large number of 0 values in replicate pots.

FACTORS AFFECTING SOIL PERSISTENCE OF TRIAZINE HERBICIDES USED WITH TRIAZINE RESISTANT RAPESEED

R.B. McKercher and R. Ashford

ABSTRACT

The development of triazine-resistant rapeseed provides a means for chemical control of stinkweed and mustard in rapeseed. The most promising chemicals for this purpose are the various substituted triazines (s-triazine). However, little research has been conducted on these chemicals with different soil types in Saskatchewan. Three chemicals, metribuzin, cyanazine and atrazine (Simazine) are being tested on a range of Saskatchewan soils of varying organic matter and texture. The tests include field testing and laboratory bioassay and gas chromatography analyses. Analyses are incomplete but from those available it seems that residues will not be a problem in Melfort soils and that in other soils, two near Saskatoon and one near Scott, that the level of residues is not high especially for cyanazine and metribuzin.

Final conclusions await the 1983 cropping season and completion of the analyses.

BACKGROUND AND OBJECTIVES

The objectives are to gain data on the persistence of atrazine, cyanazine and metribuzin in some major soil types. The data are from field plots and laboratory analyses. Over a period of four field seasons it is hoped a range of climatic and soil moisture conditions will be observed.

EXPERIMENTAL METHOD

The field tests consist of replicated treatments of atrizine at rates from 0 to 1.5 kg per ha, of cyanazine from 0 to 6 kg per ha, and of metribuzin from 0 to 0.4 kg per ha. In the first year the treatments were overseeded with Candle rape and in the second year the same plots were overseeded to a cereal or flax. In addition to seed yields, periodic field observations were recorded and yields of seed at harvest were obtained. Soil sampling for bioassay and gas chromatograph analyses was conducted at least twice per year during each year, the normal sampling being in the spring and autumn.

RESULTS AND DISCUSSION

The bioassay results of the 1981 field applications are given in Table 1. Although some residues are recorded and some reduction of oat plant

Table 1. Turnip biosassay of the 1981 field plots, fall soil samples.

Triazine applied (kg/ha)	Turnip bioassay	Tame oat plant count	Tame oat grain yield
Preston plots:			
Atrazine			
.3	NS	NS	NS
.5	*		
.75	*		
.6	*		
1.0	*	*	
1.5	*	*	
Cyanazine			
1.0	NS	NS	
2.0	NS		
3.0	*		
2.0	NS		
4.0	*		
6.0	*		
Metribuzin			
.1	NS		
.15	NS		
.2	*		
.2	*		
.3	*		
.4	*		
Kernen plots:			
Atrazine			
.3	*		
.5	*		
.75	*		
Cyanazine			
1.0	NS		
2.0			
3.0			
Metribuzin			
.1			
.15			
.2			

NS - No significant difference

* - Significant difference
numbers were recorded, no yield reduction occurred due to the surviving plants ability to tiller and produce as much grain as in the control stands.

No field residues were measured at Melfort but some barely detectable levels occurred at Scott. At Scott, atrazine showed more residues than cyanazine or metribuzin. In general the indications to date are that metribuzin and cyanazine are not likely to have significant residue levels when used at recommended field rates. Atrazine, on the other hand, will show residues but it is not registered for use. Some 500 samples remain for bioassy and gas chromatograph analyses and these will be added to by some further 1983 samples.

IMPACT

The development of triazine resistant rapeseed varieties allows the control of weeds, which have up to now proliferated, by chemical herbicides. The information to date suggests certain s-triazine herbicides may be used without developing significant soil residues. Providing our preliminary data is supported in further tests, a significant advance in rapeseed husbandry will be available to growers.

USE OF TRIAZINE HERBICIDES IN NORTH EASTERN SASKATCHEWAN

Ken Goudy

ABSTRACT

The use of s-triazines could well offer the only real solution to controlling the serious broadleaf weed problem in rape. One of these chemicals, specifically atrazine has resulted in serious residual problems with crops in subsequent years where this product has been used. Research and demonstration plot work to date, carried out on high organic matter and finer textured soils of northeastern Saskatchewan, has shown great promise for the use of the s-triazines metribuzin, cyanazine, and even atrazine on triazine resistant rape.

BACKGROUND AND OBJECTIVES

Rapeseed is generally grown in a farmer's crop rotation once every three to five years in this area. Not being able to control stinkweed and wild mustard in rape crops has resulted in these weeds becoming an increasingly serious problem in these crops. The longer the producer has been growing rape and the more frequently he grows it, generally the worse is his problem.

Even though summerfallow often appears in the same rotation as rape it doesn't normally follow the rape crop. So it is important that there is no biologically active residue of these products left in the soil to effect the crops which follow rapeseed in a rotation.

The major objectives are to determine the herbicidal activity of these three triazines on stinkweed and wild mustard when used either post emergent or pre-emergent. We also want to determine the crop tolerance of the triazine resistant rape; and the tolerance of following crops to any plant active residue left by these products. The herbicidal activity of these products on other common broadleaf weeds is also of interest.

EXPERIMENTAL METHOD

The plots were laid out with triplicate treatments in randomized blocks 5 x 15 meters with treatments in 1980, 1981 and 1982. We moved from predominantly pre-emergent applications in 1980, to predominately post emergent in 1981 and 1982. Tests were conducted in Melfort and Tisdale, the later in conjunction with Mr. Gerald Coulter and Mr. Gordon Cresswell.

The experimental sites were flat and uniform in soil type. In Melfort, the organic matter level was 8%; in Tisdale 4-6%. Spray applications were made at 10 gpa. through 6502 nozzles at 4 mph and 40 psi.

COMPOUNDS AND FORMULATION EVALUATION

ATRAZINE 80 W
CYANAZINE 80 W
METRIBUZIN 5 F

In 1980 the target crop was triazine resistant Candle rape, in 1981 triazine resistant Tower rape. In 1981 the crops used to check residual injury were wheat, barley, and flax. In 1982 the crop to check residual injury was wheat.

RESULTS AND DISCUSSION

The three years we have run this program, 1980-1982 have provided the ultimate in weather extremes. 1980 was hot and dry, no rain until June 23. 1981 was hot and dry, no measurable rain until July 15th. 1982 was cold and damp, with 5-6 inches of snow as part of 4 inches of moisture on May 27-30th.

1. Weed Control - Tables I, II, IV, VI, VII

The weed control from the post emergent applications were considerably better than that from the preplant soil incorporated applications for Atrazine and Cyanazine about 20-30% in Melfort and 10-15% in Tisdale. Preplant incorporated treatments of Metribuzin were about equivalent to

post emergent treatments. See Graph I and II. We used wettable powder formulations, since there is generally even better post emergent control with these products, when used in the oil base formulations, it was decided that in the interest of economics and reduced residual problems, we would concentrate on post emergent applications in future studies.

Atrazine at 1.0-1.5 lbs ai/acre in the wettable powder form provided good control of mustard and stinkweed, applied post emergent.

Cyanazine at 1.5 - 2.0 lbs ai/acre in the wettable powder form provided good control of mustard and stinkweed.

Metribuzin at 4-6 oz ai/acre provided good control of mustard and stinkweed either post emergent or pre-emergent.

2. Crop tolerance of triazine resistant rape - Table VI

No tolerance ratings were made in 1980 because of the very poor germination in all the treatments. There was virtually no crop.

In 1981, Cyanazine and Atrazine showed very little crop injury when applied post emergent in Melfort on ratings taken 15 days after treatment.

Metribuzin showed considerable burning to the rape crop even at the 4 oz ai rate, and more at the 6 oz rate.
A late in the season rating in 1981 showed no detectable injury from any of the treatment either in Melfort or Tisdale.

3. Residual triazine injury - See Tables III, V, VIII

To date we have not been able to detect any crop injury or yield loss on crops following any of the treatments on the black soils around Melfort. This includes rates of Atrazine from 2.0-2.5 lbs ai/acre in either 1981 or 1982; Cyanazine at rates up to 3.0 lbs, and Metrabuzin at 6 oz ai/acre show no residual injury either. In Tisdale there was no residual injury on any treatments made in 1980, on rates up to 1.5 of Atrazine. The 1981 site was not evaluated because it was summerfallowed in 1982.

It is interesting to note that the weather in 1980 and 1981 contributed to better yields on the high rates of triazines than in the untreated in both Melfort and Tisdale. See Tables III, V.

The best yields were provided by the treatments that showed the best weed control. The crop stand was so light in 1980 we had a summerfallowing effect. The better the weed control in 1980 the better the yield in 1981. See Table IV Weed Control 1980 and V Wheat Vigour in 1981.

IMPACT

Left uncontrolled, this broadleaf weed problem will greatly diminish the rapeseed acreage in Western Canada.

In 1982 alone, wild mustard and stinkweed could well have cost rapeseed growers in North Eastern Saskatchewan $20,000,000 to $40,000,000 in lost crop. Lost crop that was worked down and left fallow or reseeded and lost to frost. Lost crop due to the competition from these weeds in the crops that were left. Not to mention the mental anguish caused when a farmer has to decide on whether or not to apply the only control measure he has at his disposal to date, a cultivator.

The s-triazines will certainly provide adequate control of mustard and stinkweed at rates that are safe on the target crop, and rates that leave a low enough biologically active residue to be safe for the following crops.

This research project has provided us with rate information and timing of application guide lines to safely advance to larger demonstration plot work, i.e. the 1982 FarmLab and Chemical Company program on Triazine resistant rape.

It would appear from these results that there is good reason to continue to study atrazine in this area. It certainly would appear to supply the best possible weed control at the lowest possible price. At a saving of $5-$6/acre as compared to Bladex. If 500,000 to 1,000,000 acres/year were suitable for Atrazine, this would mean an annual savings of $2,500,000 to $5,000,000/year.
Further study on the control of additional weeds and what soils Atrazine would be safest on can be best carried out through a demonstration research program. This greatly expands the exposure of these products to varied weed problems, varied soil types, and varied climatic and field conditions.

WEED CONTROL - Pre emergent vs. post emergent treatments
Deep incorporated

0 - no control
9 - complete control

Table I: Experiment # KGAC3-80 and #KGAC5-80
PPI Application May 6/80
Post Application July 9/80
Evaluation July 25/80
Tisdale Stinkweed

	1.0 lb/a atrazine	1.5 lb/a cyanazine	4 oz/a metribuzin
PPI	7.0	7.5	8.6
POST	8.3	-	9.0

Table II: Experiment #KGAC2-80
PPI Application May 5/80
Post Application June 25/80
Evaluation - July 7/80

Melfort Wild Mustard
Stinkweed

	1.5 lb/a atrazine		2.0 lb/a cyanazine		5 oz/a metribuzin	
	Wild Mustard	Stinkweed	Wild Mustard	Stinkweed	Wild Mustard	Stinkweed
PPI	5.1	6.2	6.6	5.8	8.1	7.7
POST	8.7	8.7	6.8	8.8	-	-

Table III: Crop Injury
Wheat Yield

Experiment #KGAC2-80-81 (Melfort)
Sprayed - June 25/80
Evaluated for crop injury - August 1/81
Evaluated for yield - September 9/81

0 = total destruction
9 = no injury
Yields taken by harvesting a 4 foot swath 50 feet long out of each plot.

	Atrazine		Cyanazine		Metribuzin	
Rate	Injury rate	Yield bu/a	Injury Rate	Yield bu/a	Injury Rate	Yield bu/a
1.5 lb/a PPI	6.3	42.5	-	-	-	-
2.0 lb/a PPI	-	-	7.0	46.3	-	-
6 oz/a PPI	-	-	-	-	8.0	47.0
.75 lb/a PPI & 1.5 lb/a Post	8.6	47.7	-	-	-	-
1. lb/a PPI & 2 lb/a Post	-	-	8.6	49.0	-	-
Untreated control	6.0	40.0	6.0	40.0	6.0	40.0

Table IV: Weed Control
Experiment #KGAC3-80 and 5-80 (Tisdale)
PPI application - May 6/80
Post applciation - July 9/80
Evaluation - July 25/80

*2.25 lb of atrazine = 0.75 lb/a PPI and 1.5 lb/a post emergent

0 = complete destruction
9 = no injury

Rate	Atrazine	Cyanazine	Metribuzin
1.0 lb/a Post	8.3	-	-
1.5 lb/a Post	9.0	-	-
2.25* lb/a PPI	9.0	-	-
1.5 lb/a PPI	-	8.0	-
4 oz/a Post	-	-	9.0
5 oz/a PPI	-	-	8.4

Table V: Wheat Crop Vigour Rating (Tisdale)

Experiment #KGAC3-80-81 and
#KGAC5-80-81
PPI application - May 6/80
Post application - July 9/80
Evaluation - August 19/81

0 = complete destruction
9 - no injury

Rate	Atrazine	Cyanzine	Metributzin
1.0 lb/a Post	7.0	-	-
1.5 lb/a Post	8.6	-	-
2.25 lb/a PPI	7.6	-	-
Untreated Control	6.0	6.0	6.0
1.5 lb/a PPI	-	7.6	-
4 oz/a Post	-	-	8.0
5 oz/a PPI	-	-	7.6

Table VI: Weed Control (Stinkweed and Wild Mustard)
Crop Vigour (Tr. Rape)

Experiment #KGAC6-81 (Melfort)
**Post application - July 13/81
*Post application - July 17/81
Evaluated - August 5/81

0 = no control
9 = complete control

	Atrazine**		Cyanzine*		Metribuzin*	
Rate	Weed Ctrl	Crop Vig.	Weed Ctrl	Crop Vig.	Weed Ctrl	Crop Vig.
1.0 lb/a	7.7	8.0	-	-	-	-
1.5 lb/a	8.0	9.0	-	-	-	-
2.0 lb/a	8.7	8.8	-	-	-	-
1.5 lb/a	-	-	8.3	9.0	-	-
2.0 lb/a	-	-	8.7	8.3	-	-
3.0 lb/a	-	-	8.7	8.0	-	-
4 oz/a	-	-	-	-	8.3	7.3
6 oz/a	-	-	-	-	8.7	7.0

** The atrazine went on under extreme drought conditions followed by a good rain July 14th.

Table VII: 1981 Weed Control (Broadleaf)

Experiment #KGAC 7-81 (Tisdale)
Post application - June 25/81
Evaluation - August 19/81

0 = no control
9 = complete control

Rate	Atrazine	Cyanazine	Metribzin
.75 lb/a	7.8	-	-
1.0 lb/a	8.1	6.0	-
1.5 lb/a	8.5	7.5	-
2.0 lb/a	8.5	8.1	-
3.0 lb/a	-	8.4	-
4 oz/a	-	-	6.8
6 oz/a	-	-	8.2

Table VIII: Wheat Crop Vigour
Wheat Yield bu/a

Experiment #KGAC 6-81-82 (Melfort)
**Post application - July 13/81
*Post application - July 17/81
Evaluation - August 10/82

0 = complete destruction
9 = no injury

Rate	Atrazine**		Cyanazine*		Metribuzine*	
	Vigour	Yield	Vigour	Yield	Vigour	Yield
0 lb/a	-	51.0	-	51.0	-	51.0
1.0 lb/a	9.0	52.0	-	-	-	-
1.5 lb/a	9.0	47.5	9.0	52.5	-	-
2.0 lb/a	9.0	49.0	9.0	47.0	-	-
3.0 lb/a	-	-	9.0	50.0	-	-
4 oz/a	-	-	-	-	9.0	49.0
6 oz/a	-	-	-	-	9.0	52.0

THE DEVELOPMENT OF RECOMMENDATIONS FOR ECONOMIC SEEDING RATES OF FABA BEANS AND AN EVALUATION OF SEEDERS FOR SOWING PULSE CROPS

G.G. Rowland, R. Graf and R. Kehrig

ABSTRACT

The faba bean cultivar Outlook and the population Chinese Broad Bean were sown at six densities ranging from 13 to 75 plants/m^2 at both Saskatoon and Hagen. For Outlook a maximum yield was reached between 25 to 37

plants/m^2 while for Chinese Broad Bean it was 37 to 50 plants/m^2. At Saskatoon the fertilization frequency of flowers of the Chinese Broad Bean was higher than Outlook and plant density appeared to have no significant effect on this character.

To date 12 companies have supplied 15 seed cups for evaluation with pulse crops. A testing system has been designed to test these seed cups both in the laboratory and the field.

BACKGROUND AND OBJECTIVES

(A) Given the cost of seed for both faba beans and broad beans it is important that farmers be able to calculate their maximum return for particular seeding rates. In addition it has been suggested that pod set and thus flower fertility might be affected by planting density. Therefore the objective of this part of the study was to determine optimum seeding rates of small and large seeded faba beans and to examine if planting density had an effect on flower fertility.

(B) Pulse crops vary tremendously in their size and shape and this can lead to quite severe damage in seed cups. The objective of this second part of the study is to obtain a wide range of seed cups or seed metering devices and test them with faba beans, broad beans, chickpeas, lentils, peas and dry beans. A list of suitable seed cups for a particular seed type could then be drawn up.

EXPERIMENTAL METHOD

(A) The Outlook faba bean and the Chinese Broad Bean were sown at seeding rates of 13, 25, 38, 50, 63 and 75 plants/m^2 at both Saskatoon and Hagen. The experiments were replicated six times. Flowers were collected from each plot from the first five flowering nodes in order to determine flower fertility. Detailed notes were also kept on numbers of flowering nodes, flowers produced and mature pods. The seed yield of each plot was also determined.

(B) A single row seeder with a flexible drive system was designed and built to accommodate the various types of seed cups. The individual seed cups can be mounted on metal plates which fasten to a small seedbox on the drill. The seeder is equipped with a variable speed unit which allows testing at different r.p.m. both in the field and the laboratory with a full range of pulse crops.

RESULTS AND DISCUSSION

(A) The results in Table 1 clearly show that the minimum acceptable seeding rate for faba beans is 25 plants/m^2 or 250,000 plants/hectare. While there was some effect of seeding rates on flower fertilization the fertility frequency appeared to be adequate at all levels (Table 2).

Table 1. Yield in kg/ha at the six plant populations.

Seeding rate plants/m^2	Saskatoon		Hagen	
	Outlook	Chinese B.B.	Outlook	Chinese B.B.
13	2789	1682	2655	2422
25	3398	1986	3196	3051
38	3488	2243	3777	3437
50	3598	2418	3689	3640
63	3571	2303	4067	3538
75	3739	2364	3901	3560

Table 2. The % fertilization at Saskatoon for the various plant populations and ovary-ovule positions.

Seeding rate plants/m^2	Ovule position within the ovary							
	Outlook				Chinese B.B.			
	1	2	3	4	1	2	3	4
13	80	78	71	69	84	79	72	71
25	75	75	71	64	92	92	87	75
38	80	77	68	62	89	87	80	68
50	71	71	64	61	93	83	76	68
63	85	83	77	67	82	72	65	67
75	74	74	69	59	74	73	67	41

(B) The following companies supplied the 15 seed cups that will be tested on the six pulse crops.

Aitchison	- New Zealand
Co-op Implements	- Winnipeg
Crustbuster	- Kansas, USA
International Harvester	- Edmonton
John Deere	- Ontario
Lilliston	- Georgia, USA
Massey Ferguson	- Ontario
Midland	- Mississippi, USA
Morris	- Yorkton
Tye	- Texas, USA
Versatile-Noble	- Winnipeg
Duncan	- New Zealand

IMPACT

Growers will have for the first time Western Canadian recommendations for seeding rates of faba beans relative to their seed costs and return for the product. They will also have recommendations as to what seed cups are best suited to a particular pulse crop.

FORAGE CROPS

BREEDING LEAFCUTTING BEES ADAPTED TO THE SASKATCHEWAN ENVIRONMENT

G.H. Rank

ABSTRACT

The second round of selections in a commercial population was made. Apparently superior females were identified on the basis of their ability to fill tunnels more quickly under three different environment conditions. Selections from the previous year were evaluated in three different field locations. Drifting within sites was evaluated by marking a small population of bees with paint on the upper thorax. Over the summer the number of filled tunnels was monitored on a weekly basis. A comparison of strains was performed in the laboratory during the winter months to evaluate the following: cocoon weight, pupal weight, parasite infestation, sex ratio, diapause development, emergence time, and chromosome morphology.

BACKGROUND AND OBJECTIVES

Our objective was to evaluate strains from the previous years selection and to perform new selections for evolution in 1983.

EXPERIMENTAL METHOD
RESULTS AND DISCUSSION

1) Evaluation of 1981 Selections

Selections in 1981 were made on the commercial populations at the farms of Mrs. D. Mumm and the Hazelridge Co-operative at Shellbrook, Saskatchewan. These selections referred to as ES 81 were based on the identification of tunnels filled early in the year by individual females.

ES 81 was compared to the standard commercial strain (CO 81) at three locations near Saskatoon. Three locations were chosen which represented variable habitats: Habitat A - hilly exposed dryland; Habitat B - small field surrounded by native vegetation; Habitat C - exposed field under irrigation.

Bees were placed in the field with access to identical shelters and hives. For each plot one hive was placed on the south side of a 4 x 8 ft. plywood shelter with the open face oriented magnetic northeast. Approximately 500 females and 1000 males were released at each site. In addition 75 females were marked by placing a small amount of paint on the upper throax. At weekly intervals the number of marked bees was determined (Table 1). The information on filled tunnels and the filled tunnels per released female is given in Tables 2 and 3. These data suggested approximately 20% drifting and very little difference in the

performance of selected and commercial bees. However, final evaluation will depend on the yield of bees determined by harvesting hives which contain filled and partly filled tunnels.

2) 1982 Selections

Selections based on early filled tunnels were made at Shellbrook for evaluation in 1983.

In addition, we were influenced by the interest expressed in univoltine strains (producing only one generation per year) by a number of scientists and producers at the 1st International Symposium on Leafcutter Bee Management held in Saskatoon, August 16-18. Eight early filled hives (approximately 250,000 prepupae) were placed at 30°C in the incubation room of Mrs. D. Mumm. They were incubated for 55 days until approximately 30% of cells released adult bees. The remainder are presumed to have gone into a firm diapause and will be used for additional selections in 1983.

3) Collaborative Research

Dr. J.N. Tasei of the Institut National de la Recherche Agronomique, Lusignan, France reported on the performance of one of our selections at the 1st International Symposium on Leafcutting Bees. Our strain ("Rank" Canadian Strain) was shown to be much more efficient in the collection of alfalfa pollen compared to a standard French strain (Fig. 1). We will continue this collaboration in 1983.

IMPACT

It is still premature to evaluate the impact of our breeding research on the industry. I am hopeful that by the end of this summer we will be in a position to determine for certain if our breeding program has had any success in selecting a superior bee.

Table 1. Total marked bees observed at three sites.

	Date							
	20.07		27.07		03.08		10.08	
Location	A[1]	B[2]	A	B	A	B	A	B
Habitat A	0	0	18	6	11	6	1	0
Habitat B	2	0	12	1	7	0	4	1
Habitat C	0	0	14	3	18	2	0	0
Total	2	0	44	10	36	8	5	1

[1] A column - marked bees observed at release site
[2] B column - marked bees observed away from release site

Table 2. Cumulative total of tunnels filled.

Location	Date					
	20.07	27.07	03.08	10.08	24.08	31.08*
Habitat A						
ES 81 - rep 1	5	115	327	510	676	670
ES 81 - rep 2	2	97	292	412	523	514
CO 81 - rep 1	7	152	368	547	727	722
CO 81 - rep 2	1	83	250	382	536	533
Habitat B						
ES 81	4	152	309	436	558	556
CO 81	0	99	267	389	509	503
Habitat C						
ES 81	5	148	361	508	665	662
CO 81	3	150	379	537	730	741

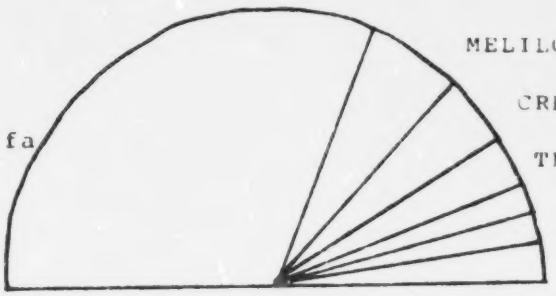
*Decline from 24.08 due to small emergence of second generation.

Table 3. Filled tunnels per released female.

Selection Locations	No. of females placed	No. tunnels filled	Tunnels Filled/ Females
Habitat A			
ES 81 - rep 1	543	676	1.24
ES 81 - rep 2	543	523	0.96
CO 81 - rep 1	493	727	1.47
CO 81 - rep 2	493	536	1.09
Habitat B			
ES 81	543	558	1.03
CO 81	493	509	1.03
Habitat C			
ES 81	543	665	1.22
CO 81	493	730	1.48

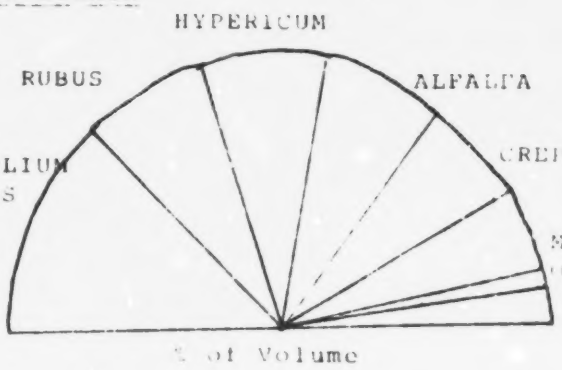
Figure 1. Pollen Collection by MEGACHILE ROTUNDATA

"RANK" CANADIAN STRAIN



3 ♀
10% samples

FRENCH STRAIN



41 ♀
17% samples

DEVELOPMENT OF A TRISOMIC SERIES IN RUSSIAN WILDRYE (ELYMUS JUNCEUS)

G. Scoles

ABSTRACT

The aim of this project is to create and then evaluate lines of Russian Wild Ryegrass (Elymus junceus) carrying an extra chromosome. These lines will be of value in associating traits such as height, maturity, leafiness, forage yield and quality with specific chromosomes. Such knowledge will be of use in breeding new cultivars of this species. Almost 100 plants carrying an extra chromosome have been examined. From this material six of the seven possible trisomics have been identified.

BACKGROUND AND OBJECTIVES

Russian Wildrye is a major dryland pasture grass in Saskatchewan. A continuing breeding program at Swift Current has resulted in the licensing of several new varieties. However, genetic information on Russian Wildrye is virtually non-existent since most plants look alike. One method by which genetic information can be obtained is through the establishment of a trisomic series. This project was established to develop such a series and to characterize genetically and phenotypically the seven different trisomics in Russian Wildrye.

EXPERIMENTAL METHOD

A potential source of trisomic plants was established by crossing diploid and autotetraploid Russian Wildrye and allowing the triploid progeny to cross-pollinate with diploid plants. Seed formed on these plants should have had chromosome numbers from 14 to 21 and plants were established in the field from about 900 seeds.

These plants were analysed meiotically in order to identify those having 15 chromosomes. Seed from these trisomic plants was analyzed to identify the trisomic chromosome in order that the trisomic series can be established and further investigated.

RESULTS AND DISCUSSION

By karyotype analysis of root-tips from a number of seedlings a standard karyotype for Russian Wildrye has been developed. Karyotype analysis of 15 chromosome seedlings obtained from trisomic plants has allowed the identification of six of the seven trisomics. In some cases two or three plants carrying the same chromosome in the trisomic condition have been identified. In such cases the different trisomics appear to have a similar phenotype in terms of height and tillering pattern. This would tend to confirm that these plants are trisomic for a common chromosome as suggested by karyotype analysis.

This summer we plan to continue root-tip analysis in order to identify the seventh trisomic. Small plots of the six identified trisomics will be established and material will be collected to analyse the meiotic behavior and transmission of the trisomic chromosomes.

IMPACT

The development of a trisomic series in Russian Wildrye will allow a considerable amount of genetic information to be obtained with regards to this crop. At present there have been no studies on the genetic basis of either seed or forage yield or forage quality. A trisomic series would permit the association of a number of traits related to these breeding objectives with specific chromosomes and thus would allow the linkage groups to be determined. Each chromosome carries a number of genes which in turn determine a number of characters. These characters are linked and tend to be inherited as a single unit. In a breeding program considerable work and time may be required to break this linkage by recombination. Alternately, characters from different linkage groups can be combined in a new variety with relative ease. Such knowledge is of value in a breeding program and can be utilized in the development of improved varieties.

AN EVALUATION OF WINTER HARDINESS IN SASKATCHEWAN FORAGE GRASSES

A.E. Limin and D.B. Fowler

ABSTRACT

The cold hardiness level of 36 forage varieties grown in Saskatchewan has beenesulting loss of productivity in forage crops. The single most important cause of winter injury is low temperature stress. To survive the winter the plants must begin to cold acclimate during cool fall weat evaluated in the seedling stage of development. The varieties were ranked in the order of their cold hardiness level. There were considerable differences found in the hardiness level between varieties within a species as well as between species. The most hardy forage varieties were found to be approximately equal in hardiness to Norstar winter wheat. The nonhardy varieties were considerably less hardy suggesting that winter-kill may become a problem if these varieties are fall planted.

BACKGROUND AND OBJECTIVES

The severe winter climate of Saskatchewan can cause winter injury and a rher and must reach maximum hardiness by freeze-up. The degree of low temperature exposure in a given year will be determined in part by the amount of snow-cover and by the geographical location.

This research project was initiated to evaluate the winter hardiness of forage grasses grown in Saskatchewan. The factors to be evaluated are: the relative levels of cold hardiness of recommended forage varieties in the seedling stage as well as in established stands, the rate of cold hardening in the fall and the rate of dehardening in the spring, and the mechanism of winter survival used by several species. This information would provide a valuable guide for the selection of species and varieties best adapted for a particular area of the province.

EXPERIMENTAL METHOD

The seed of a total of 36 forage grasses grown in Saskatchewan were collected for cold hardiness evaluation. Most of this seed was kindly supplied by Dr. R.P. Knowles (Agriculture Canada, Saskatoon) and also by Dr. T. Lawrence (Agriculture Canada, Swift Current). The method of cold acclimation and freeze testing used was similar to that already established for evaluating the cold hardiness of cereal grains. The seeds were germinated and grown in a controlled environment chamber until the 3-4 leaf stage was reached in all varieties. The temperature was then reduced to 1°C for a cold hardening period of 4 weeks followed by 3 weeks at +2°C day and -2°C night. The roots and upper leaves were then removed from the plants, the plants were covered in moist sand and placed in a freezer. The freezing rate was 2°C/h and plants were removed at the desired temperatures. The plants were then transplanted into soil for a period of 3 weeks and the temperature at which 50% were killed by frost (LT_{50}) was determined by their ability to regrow shoots and roots.

RESULTS AND DISCUSSION

All plants responded well to the growth conditions and preparation procedures for freeze testing. Unfrozen controls exhibited a 100% survival rate when transplanted for regrowth. There was considerable difference in plant size between varieties, however, all plants had approximately the same number of leaves when cold acclimation was begun. The LT_{50} ratings for all forage variety seedlings plus two winter cereals is given in Table 1.

There was considerable difference in the cold hardiness of these forages at this stage. The most striking varietal difference within a species was within the crested wheats where Nordan had an LT_{50} of -14.5 and Summit had an LT_{50} of -21.5. The most cold hardy of the forages, at the seedling stage of development, are approximately equal to the winter wheat variety Norstar but are much less hardy than Puma winter rye.

IMPACT

The considerable range of cold hardiness found in the forage varieties at the seedling stage indicate that there may be serious risk involved if fall planting of the nonhardy varieties is attempted. The results suggest that in most areas of Saskatchewan only the more hardy varieties should be considered for fall planting. Seeding into a cover of stubble

would help to assure winter survival of all planted crops by providing an insulating blanket of snow. The seeding date probably should not be later than the date recommended for winter wheat and the seedbed should have sufficient moisture to ensure germination and adequate growth prior to winter.

Table 1. The LT_{50} rating (temperature at which 50% of the population is killed) of 36 forage grass varieties and 2 winter cereals evaluated in the seedling stage of development.

Species	Common name	Variety	LT_{50}
Dactylis glomerata	orchard grass	Kay	-14
Agropyron trachycaulum	slender wheatgrass	Revenue	-14
Agropyron dasystachyum	northern wheatgrass	S-8895	-14
Agropyron smithii	western wheatgrass	S-8580	-15
Agropyron riparium	streambank wheatgrass		-15.5
Bromus inermis	smooth bromegrass	Baylor	-15
		Magna	-16
		Beacon	-17
		Carlton	-18.5
Bromus biebersteinii	meadow bromegrass	Regar	-17
		S-7414	-17.5
Elymus angustus	altai wild ryegrass	Prairieland	-17.5
Phalaris arundinacea	reed canary grass	Castor	-16
		Frontier	-18
		Vantage	-18
Agropyron cristatum	crested wheatgrass	Nordan	-14.5
		S-7317	-17
		Fairway	-18
		Parkway	-18.5
		Summit	-21.5
Festuca ovina	hard fescue	S-1792	-19
Phleum pratense	timothy	Champ	-18.5
		Climax	-19.5
		Basho	-20
Agrostis palustris	creeping bentgrass	S-4979	-14.5
Festuca rubra	creeping red fescue	Boreal	-19
			-20
Elymus junceus	Russian wild rye grass	Cabree	-19.5
		Mayak	-20
		Sawkji	-21
		Swift	-21.5
Agropyron intermedium	intermediate wheatgrass	Greenleaf	-22
		Chief	-23
		Clarke	-23.5
Poa pratensis	Kentucky bluegrass	Dormie	-24.5
Agropyron elongatum	tall wheatgrass	Orbit	-25
Triticum aestivum	winter wheat	Norstar	-24
Secale cereale	winter rye	Puma	-32.5

HORTICULTURAL CROPS

WEED CONTROL IN COMMERCIALLY PRODUCED ONIONS

D.H. Dabbs

ABSTRACT

A rather wide range of herbicides and herbicide combinations were assessed on this crop in 1982. Some of these had been tested previously, but several of them were new. A number of treatments performed extremely well. Within the very limited number of presently registered herbicides the best combination was CIPC at 3.0 kg ai/ha applied early postplant, followed by Hoegrass at 1.0 kg ai/ha when the grassy weeds had 1 to 4 leaves, in turn, followed by Totril at 0.5 kg ai/ha when the onions had three leaves. Even this relatively low rate of CIPC showed some phytotoxicity to germinating onions on a sandy loam soil with a very low organic matter content. Both propachlor (Ramrod) and pendimethalin (Prowl) showed promise as a possible replacement for CIPC.

BACKGROUND AND OBJECTIVES

Saskatchewan growers are presently producing less than one percent of the onions consumed by the citizens of this province. There is no one simple reason to explain this shortage of Saskatchewan grown onions, but it is certain that one of the major constraints has been the uncertainty of obtaining a sufficiently reliable level of weed control. This particular project is part of an ongoing search for more reliable weed control measures that can be utilizied by commercial producers of winter storage onions.

EXPERIMENTAL METHODS

A total of 33 different herbicides and herbicide combinations were assessed on the onion variety Autumn Spice in replicated and irrigated trials on a fine sandy loam soil at Outlook and on a Bradwell clay loam at Saskatoon in 1982. Four rows of onions were used per plot and the rows were spaced 40 cm apart. All records were taken from the two centre rows only from each of the four replicates. The herbicide treatments were applied at the appropriate times with a specially designed, small plot sprayer, and irrigation water was applied, as needed, by means of overhead sprinklers in order to maintain the soil moisture level at a minimum of 50 percent of field capacity. There was no cultivation of any of the plots following the seeding operation excepting for the hand-weeded check.

Notes on the effectiveness of weed control, as well as on phytotoxity to the onions, were made several times during the growing season. Total weights of onion bulbs, plus tops, were recorded at the end of the growing season and the results of the trials were published in the 1982 Proceedings of the Expert Committee on Weeds (Western Canada).

RESULTS AND DISCUSSION

Some valuable additional information was obtained from these trials, as well as further confirmation of the indicated effectiveness of some of the treatments used in 1981. Probably the major result that fell within this latter category was the confirmation that CIPC at two thirds of the normal recommended rate (ie. at 3.0 kg ai/ha) was sufficient to adequately control the first flush of weeds with much less danger of resulting in a decreased stand of onions. At the present time this is the only registered herbicide for use on onions that will adequately control this first flush of weeds in Saskatchewan. If these weeds are not controlled the onions may become completely over-run before the rows are sufficiently evident to allow shallow row cultivation, and these weeds may be too large to control with post-emergent herbicides by the time the onion plants have reached a growth stage that will allow the use of these latter herbicides.

Of the extremely limited number of registered materials that are presently available to Canadian onion growers the best combination in 1982 was chlorpropham (CIPC) at 3.0 kg ai/ha applied early postplant, followed by diclofop methyl (Hoegrass) at 1.0 kg ai/ha for the control of grassy weeds, applied when this group of weeds were in the 1 to 4 leaf stage, in turn, followed by ioxynil (Totril) at 0.5 kg ai/ha for broadleaved weed control when the onions had three leaves. As indicated earlier, this rate of CIPC was only two thirds of the normal recommended rate, but even at this rate there was some reduction of onion plant stand at Outlook in the fine sandy loam soil containing only 1.6 percent organic matter. There was no such reduction in onion plant stand in either a fine sandy loam containing 2.4 percent organic matter at Outlook or in a Bradwell clay loam at Saskatoon containing 4.0 percent organic matter. Until a replacement herbicide becomes available most field situations will demand this early application of CIPC if there is to be any possibility of success and it may well necessitate seeding at a slightly higher rate on some of the very light textured soils.

The 1982 results again showed that tank-mixing of the two extremely valuable and registered post-emergent herbicides Hoegrass and Totril was at least as effective as using them separately, providing the grassy weeds do not become too large by the time the onions have reached the three leaf stage. The Hoechst company is very interested in this concept of tank-mixing their product with Totril and will likely pursue a label registration. This also has financial implications by reducing the time and fuel requirements needed to keep weeds under control.

Propachlor (Ramrod), which is registerd for use on onions in some countries, again proved that it could be a safe replacement for CIPC. At both Outlook and Saskatoon this herbicide, also applied early postplant, gave nearly perfect control of the first flush of weeds and showed no deleterious effect on the onions. Its' effect is short-lived and in most situations would also need to be followed by both Hoegrass and Totril.

Another promising replacement for CIPC would appear to be pendimethalin (Prowl). Used at 1.5 kg ai/ha in 1982, preplant incorporated, followed only by ioxynil at 0.5 kg ai/ha, this material resulted in an excellent crop of onions that were totally weed-free. There is no certainty at this point in time that either of these two herbicides will ever be registered for use on onions, but there is hope.

A number of other new herbicides were also on test and some of these performed extremely well. Of special interest are four "grassy" herbicides that show no deleterious effect on onion plants and control a considerably wider range of grassy weeds than does Hoegrass. At least one or two of these will likely be registered on one or more horticultural crops in the near future and will probably eventually be registered for use on onions.

It is essential that research of this nature be continued until a totally safe and highly effective set of weed control recommendations can be formulated for use on irrigated, commercially-produced onions.

IMPACT

A totally safe and completely reliable combination of treatments for controlling weeds in onions would remove one of the major constraints presently preventing a greatly increased level of onion production in Saskatchewan, and help very materially to improve our balance of payments situation.

PUBLICATIONS

1. D.H. Dabbs, "Weed control in onions on a Bradwell clay loam, Saskatoon, Sask.", Res. Report Expert Comm. on Weeds (West. Canada), 29 (1982), 429.

2. D.H. Dabbs, "Weed control in onions on a Bradwell clay loam, Saskatoon, Sask.", Res. Report Expert Comm. on Weeds (West. Canada), 29 (1982), 430.

3. D.H. Dabbs, "Weed control in onions on an Asquith fine sandy loam, Outlook, Sask.", Res. Report Expert Comm. on Weeds (West. Canada), 29 (1982), 431.

UTILIZATION OF WASTE-HEAT FROM A POTASH MINE FOR PROTECTED CULTIVATION

E.A. Maginnes and G.H. Green

ABSTRACT

During the past year research has continued on heating the experimental greenhouse at the Lanigan Potash Mine by passing warm mine exhaust between the two layers of polyethylene covering the structure. Exhaust air at mine level is 27°C (80°F) and has the potential of reducing heating costs by 80 percent. However, air infiltration through the heat frame at ground level reduces the temperature to as low as 15.5°C (60°F) during the coldest part of the year. Under these conditions there is no potential energy saving.

Reduction in the amount of fine dust in the exhaust has proven to be uneconomical. Further, dust that built up on the inner poly layer could not be satisfactorily removed.

In order to overcome the dust-heating problem, an experiment is being conducted to introduce the air directly into the greenhouse in a system of perforated ducts.

BACKGROUND AND OBJECTIVES

According to a Canadian Institute of Mining Report (Feb. 16, 1981), there are a total of 97 underground mines in Canada with a daily production of 353,000 tons that exhaust approximately 32 million cubic feet of air per minute. The overall annual temperature range of this air is 40° - 90°F, and the winter range is approximatley 45° - 55°F in metal mines, 60° - 70°F in coal mines, and 75° - 85°F in potash mines. In the case of potash mines it is not presently economically possible to use the exhaust in the operation and thus non-mining uses such as greenhouses appear to be an alternative. A successful greenhouse heating system will enhance the economics of greenhouse fruit and vegetable production as well as to drastically reduce or eliminate the energy required for conventional heating.

The exhaust air at mine level in the Lanigan Mine is 27 - 30°C (80 - 86°F), has a relative humidity from 25-30%, and contains about .015 kg/m^3 (.000425 lbs/ft^3) of fine particulate matter. Using this exhaust, the experimental ground level greenhouse will be used to test various approaches to exhaust gas heating and its influence on plant growth.

EXPERIMENTAL METHOD

Testing continued on the 7.9 x 14.6 m (26' x 48') greenhouse erected in 1981 (Figure 1). The exhaust air for heating was supplied by a 14-foot horizontal exhaust fan which released 120 m^3/sec (250,000 cfm) at high speed. Another exhaust fan is located at mine level near the base of the exhaust shaft.
For the entire 1982 season there was a pad filter built into the wooden duct to filter out some of the dust in the exhaust. It consists of standard one inch washable furnace filters. Prior to the use of the perforated duct system to introduce the air, a bag filter was installed just prior to introducing the air into the plastic ducts.

Plant growth was carried out in plastic bags containing about 15 litres of either spruce or oak shavings and fed at regular intervals with a nutrient solution.

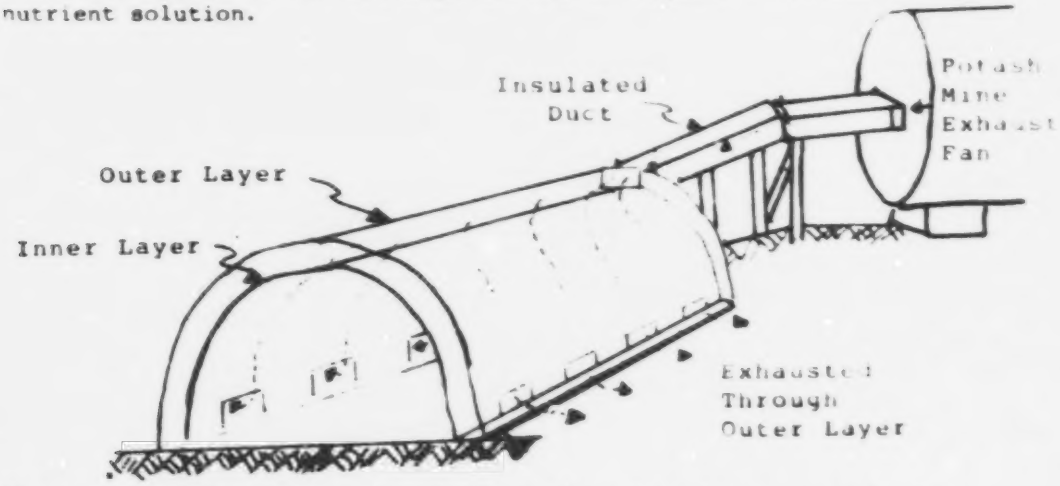


Figure 1: Schematic drawing of the Lanigan Potash Mine greenhouse

RESULTS AND DISCUSSION

Fan operation had a considerable influence on the temperature of the exhaust air leaving the ground level fan. During the period of testing only the ground level fan was in operation. Thus, this fan created a significant negative pressure in the head frame. This resulted in infiltration through the large loading door as well as through the other doors and openings to the head frame. As a result the 27 to 30°C (80 to 86°F) air leaving the mine ended up at 15.5 to 18°C (60 to 65°F) when it entered the greenhouse during the coldest portion of the year. It is impossible to heat a greenhouse to 15.5 to 18°C (60 to 65°F) when 15.5 to 18°C exhaust air is entering the greenhouse.

With the exhaust air at 18°C (65°F) being discharged directly into the growing space it has been calculated that it is only possible to grow a

low temperature crop such as lettuce at the 13°C (55°F) that would result during the colder part of the year. This type of system would require 8.49 m^3/sec (18,000 cfm) to supply 58 kW (2,000,000 btu/hr) loss for the experimental greenhouse. On the other hand the 120 m^3/sec (250,000 cfm) output of the fan would heat about 1,300 m^2 (14,000 ft^2) of greenhouse.

If the exhaust air is discharged between the two covering layers of the greenhouse and exhausted at the sides and end (Figure 1), then only 2.36m^3/sec (5,000 cfm) would be required to heat the experimental greenhouse. Under these conditions 120m^3/sec (250,000 cfm) would heat 5,752m^2 (57,000 ft^2).

It was because of the above observations and calculations that the exhaust air was introduced between the two layers of polyethylene covering the greenhouse. However, dust accumulated on the surface of the inner layer of polyethylene from January 26 until October 27 and reduced the light intensity in the growing space to a degree that hindered plant growth after this period. This was encountered even though there was a pad filter in the duct leading from the exhaust fan. Attempts to remove the dust by vibration and washing were not succcessful.

The dust buildup had no influence on the growth of cucumbers during the January 26 to October 27 period. It reduced the higher light intensity of summer as well as the temperature in the growing space. Under these conditions the temperature of the mine exhaust and the dust buildup served to produce an acceptable environment for plant growth.

Because of the problems encountered when introducing the exhaust between the covering layers, the air is being introduced directly into the growing space through a series of perforated ducts (Figure 2). It is hoped that a high efficiency bag filter installed just before the air enters the growing space will reduce the dust content to an acceptable level.

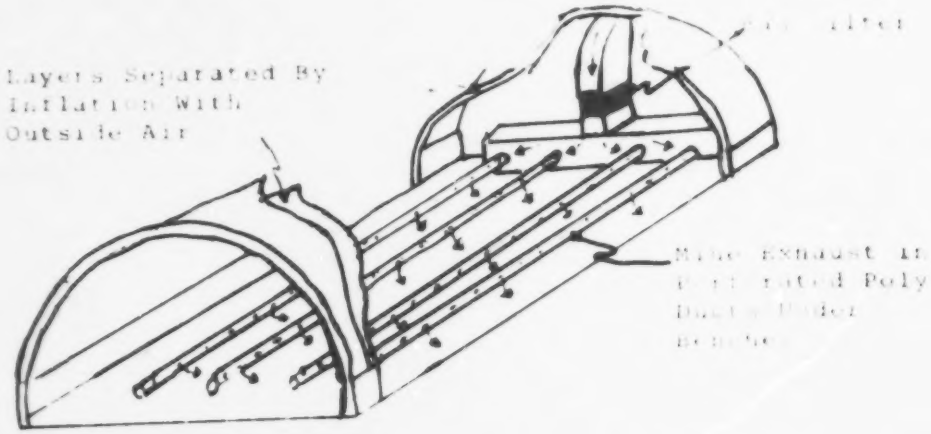


Figure 2: Schematic drawing showing perforated exhaust air ducts. Three crops of lettuce and 1 crop of cucumbers were grown in sawdust

culture this past year. All of the mature produce was of excellent quality and thought by restaurants and stores in the Lanigan area to be a good, but usually better than that normally available locally. During the period from January 26 to October 27 there was no indication that the environment of the mine site had any detrimental influence on the plants.

As a result of working with cucumbers two important facts will become part of further experimentation:

1) The growth and fruiting of cucumbers was drastically reduced as the days got shorter. Preliminary tests indicated that the use of high pressure sodium lights to extend the day helped overcome this problem. This is not yet a commercial practice.
2) The continuous production of cucumbers using vegetative propagation techniques would appear to be feasible. Terminal cuttings rooted readily and turned into fruiting plants faster than those from seed. Since the best rate of production occurs on about the first eight feet of a plant, it is possible to start the first plants from seed and then propagate successive crops vegetatively. This also is a new approach to greenhouse cucumber culture.

IMPACT

The utilization of waste heat from a potash mine for protected cultivation will reduce the energy required for conventional heating. Savings could be in the range of 80 percent of the $40,000 to $50,000 it would cost to heat one acre for a year. This would allow the local production of quality produce.

VEGETABLE VARIETAL TRIAL 1982

C.O. Green

ABSTRACT

In 1982 selections of broccoli, cherry tomato, cantaloupe, and watermelon, were tested in ten metre row trials, while cauliflower and red cabbage varieties were placed in a replicated plot. Trial sweet corn was tested on a field scale basis.

Broccoli Sixteen selections were tested including Cleopatra, Green Duke, Bravo, Green Dwarf, Italian Sprouting, Atlantic, Spartan, Waltham, Furtura, Orion, Apollo, Gem (Asgrow), Premium Green, Gem (McKenzie), Green Hornet, and Green Mountain. Green Duke and Bravo followed by Gem, Orion, and Futura were the better performers in terms of yield and quality.

Red Cabbage Six varieties-Mammoth, Red Rock, Meteor Red Storage 4044, Storage Red, Red Danish and Hybrid Red Head were tested in a replicated plot trial. Hybrid Red Head and Red Storage 4044 significantly outyielded the others while Red Storage 4044 produced the heavier weight per head.

Cauliflower Five varieties-Snowcrown (McKenzie), Snowcrown (Stokes), Y Improved, Snowflower and Snowball X were similarly grown in a replicated trial. Snowcrown was earliest but lacked adequate self-blanching character while the others were more suitable. There was no significant yield differences between the varieties although Snowcrown followed by Snowball X and Y Improved were the better performers.

Red Cherry Tomato Three varieties-Sweet 100, Minibel and Tiny Tim were tested. Sweet 100 was the best yielder with the most uniform smallest fruit and sweetest flavor. The foilage, however, was very dense which made picking very difficult.

Cantaloupe Eight varieties were grown, but no meaningful data were obtained.

Watermelon Six varieties were grown, but no meaningful data were obtained.

Sweet Corn Five varieties were tested on a field scale basis. Sunny Vee matured earliest followed by Golden Beauty, Aztec, XP2500 and Calico in that order. Both Golden Beauty and Aztec were suitable for main crop production with Aztec being the best yielder. Limited production of Sunny Vee is warranted for early market. Both XP2500 and Calico had large ears with exceptional quality, however, their late maturity limits their commercial acceptability.

BACKGROUND AND OBJECTIVES

In Saskatchewan, data is available in the unloads of fresh vegetables in Regina and Saskatoon which represent about two-thirds of the Saskatchewan market. This data indicates the volume as well as the source of the unloads.

An analysis of this data for the "in-season" period when Saskatchewan producers can grow, store and market their produce for the five year period from 1973 to 1977 indicates that other than potatoes, only 10.2 percent of those unloads come from Saskatchewan producers.

Furthermore, over the five year period that percentage has declined in spite of the fact that volumes have increased. Therefore, while more growers are producing or existing growers are expanding their production that increase is in fact not at all keeping pace with increasing demand.

Consequently, on the basis of 1977-78 average farm gate prices Saskatchewan consumers have spent an estimated $6,750,000 annually for "in-season" vegetables from other parts of Canada, but primarily the United States. Those "in-season" imports can and should be replaced with Saskatchewan production.

Assuming a conservative multiplier effect of five that means an annual loss to the Saskatchewan economy of $33,000,000 in 1977-78 dollars.

One of the serious and significant deterrants to the replacement of imports with Saskatchewan production is the lack of adequate research in vegetables. While some information is available the bulk of research information must currently be obtained from Alberta or Manitoba whose conditions are not always similar to local growing conditions.

Accordingly, Prairie Produce Ltd. is developing a research capability directly aimed at commercial production and has undertaken as part of that research the evaluation of vegetable varieties most suited to local growing conditions at Outlook.

EXPERIMENTAL METHODS

The ongoing varietal evaluations consist of firstly screening large numbers of varieties in single ten metre rows for two to three years followed by a replicated trial of four to six of the best varieties for a similar period of time and concluding with a field scale evaluation of the best two or three varieties.

In 1982 single row evaluations were undertaken on broccoli, cherry tomato, cantaloupe and watermelon, replicated evaluations on cauliflower and red cabbage and a field scale evaluation on sweet corn varieties.

RESULTS AND DISCUSSION

Broccoli Sixteen selections of broccoli were planted in Jiffy 7's in a lean-to greenhouse on April 30 and transplanted in the field on June 1. There were two harvests on August 4 and August 16.

A cool spring and less than adequate greenhouse facility may have contributed to a poorer survival rate and/or performance of some varieties. However, on the basis of these results Green Duke and Bravo followed by Gem, then Orion and Futura appeared to be the better performers.

Both Green Duke and Bravo had large uniform, dense heads. Gem was early and had very uniform heads, but was somewhat smaller than either Green Duke or Bravo, Orion lacked uniformity in that some plants failed to produce heads. Futura produced acceptable heads but did not mature uniformly. Green Dwarf, Atlantic and Waltham appeared to be the latest maturing varieties.

Broccoli:

Variety	No. Heads planted	Marketable heads harvested	%	Kg/Wt 10 metre	(Rank)	Wt/ Head gms	(Rank)	Field Rating 1-Poor 10-good
Cleopatra	22	18	82%	7.80kg	(9)	433gm	(8)	6
Green Duke	26	25	96	18.71	(1)	748	(1)	9
Bravo	23	23	100	14.13	(2)	614	(2)	9
Hybrid Green Dwarf	27	24	89	6.38	(12)	265	(15)	3
Italian Sprouting	26	23	88	9.06	(7)	394	(9)	4
Atlantic	22	19	86	5.40	(14)	284	(13)	2
Spartan Era	28	27	96	7.21	(10)	267	(14)	5
Waltham	25	18	72	6.16	(13)	342	(12)	4
Hybrid Futura	20	20	100	10.18	(6)	509	(5)	5
Orion	28	22	79	11.38	(5)	517	(4)	6
Appolo	25	25	100	3.66	(15)	261	(16)	2
Gem(Asgrow)	25	25	100	13.47	(3)	539	(3)	8
Premium Crop	19	10	53	3.64	(16)	364	(10)	4
Gem(McKenzie)	26	24	92	11.77	(4)	490	(6)	7
Green Hornet	25	24	96	8.40	(8)	350	(11)	5
Green Mountain	18	15	83	6.73	(11)	448	(7)	5

Cherry Tomato Three varieties of cherry tomato were seeded May 1, transplanted into Jiffy 7's on May 11 and field planted on June 3. They were harvested on September 17.

Variety	Kg per 10 plants Cross	Ripe	% Ripe	Kg per 10 metre row Cross	Ripe	% Ripe
Sweet 100	29.03	4.54	15.6%	42.64	4.99	11.7%
Minibel	2.04	.57	27.9%	14.06	5.44	38.7%
Tiny Tim	6.80	2.38	35.0%	29.03	4.54	15.6%

Sweet 100 produced large viny plants with very dense growth, but the fruit was small, uniform and exceptionally sweet. Since the plants were not staked harvest proved difficult because any handling resulted in broken branches. This variety was judged most suitable for commercial production, but would have to be staked in some manner to facilitate harvest.

All varieties were late maturing, however, which may limit their suitability for commercial production.

Cantaloupe Eight varieties of cantaloupe were planted in three inch peat pots on May 1 and field planted on June 3 with pots intact. Varieties planted were Hales Best Delicious 51, Classic, Iroquois, Honey Rock, Canada Gem, Honey Dew and Burpee Hybrid.

As a result of cool wet spring and inadequate greenhouse facilities many transplants were weak and/or did not survive and combined with weeds failed to produce sufficient marketable fruit to obtain any meaningful data.

Watermelon Six varieties of watermelon-Northern Delight, Yellow Baby, Stokes Sugar Hybrid, Canada Super Sweet, Sweet Favorite and Early Canada- were handled similar to cantaloupe with the same results.

Cauliflower Five varieties of self-blanching cauliflower were planted in Jiffy 7's on April 30 and field planted in a replicated randomized complete block design on June 1. There were four harvest dates on August 6, August 16, September 4, and September 18.

	Weight in Kg/10 metre Rows (No. of heads)				
Variety	Rep 1	Rep 2	Rep 3	Rep 4	Average
Snowcrown (Stokes)	8.31(10)	5.96(8)	4.77(7)	10.50(10)	7.39(8.75)
Snowcrown(McKenzie)	10.92(11)	9.31(10)	9.85(10)	4.23(7)	8.58(9.5)
Y Improved	5.45(7)	6.61(9)	3.72(5)	8.29(9)	6.02(7.5)
Snowflower	4.77(9)	4.31(6)	6.21(8)	4.03(6)	4.83(7.25)
Snowball X	3.29(7)	5.87(8)	8.00(9)	8.43(10)	6.40(8.5)

	Weight grams per head				
Variety	Rep 1	Rep 2	Rep 3	Rep 4	Average
Snowcrown(Stokes)	831	745	681	1050	827
Snowcrown(McKenzie)	993	931	985	604	878
Y Improved	779	734	744	921	795
Snowflower	530	718	776	672	674
Snowball X	470	734	888	843	734

An analysis of variance was conducted on the data with the result that there was no significant difference in yield between any of the varieties at the five percent level although Snowcrown followed by Snowball X and Y Improved tended to yield better.

Snowcrown was the earliest maturing variety, but lacked sufficient leaves to adequately cover the curd which would make harvest timing more critical to prevent yellowing especially during the early season period with its tendency to higher temperatures.

Y Improved, Snowflower and Snowball X though late all possessed an acceptable self-blanching character producing an attractive white curd.

Red Cabbage Six varieties of Red Cabbage were planted in Jiffy 7's on April 30 and field transplanted in a replicated randomized complete block design on May 31. Harvesting was undertaken on September 16.

Variety	Wt in Kg/10 metre Row (Nos. of Marketable Heads) Rep 1	Rep 2	Rep 3	Rep 4	Average
Mammoth Red Rock	.85(3)	.60(3)	.62(1)	.65(6)	.68(3.25)
Meteor	1.31(6)	1.19(6)	1.02(5)	1.19(5)	1.18(5.5)
Red Storage 4044	1.90(2)	4.99(18)	2.27(5)	1.62(2)	2.70(6.75)
Storage Red	1.22(4)	.48(3)	1.08(4)	1.65(4)	1.11(3.75)
Red Danish	.97(5)	.68(3)	.68(4)	.57(3)	.58(3.75)
Hybrid Red Head	3.06(10)	4.77(14)	2.04(3)	3.29(9)	3.29(9)

Variety	Average Weight in gms per head Rep 1	Rep 2	Rep 3	Rep 4	Average
Mammoth Red Rock	284	199	624	109	304
Meteor	218	199	204	238	215
Red Storage 4044	951	277	454	808	623
Storage Red	305	161	270	411	287
Red Danish	193	227	170	189	195
Hybrid Red Head	306	340	681	366	423

Statistical analysis indicated on the basis of yield Hybrid Red Head and Red Storage 4044 were significantly better at the 5 percent level than the other four varieties, but were not significatnly different from each.

On the basis of weight per head Red Storage 4044 was significantly heavier at the 5 percent level than all other varieties except Hybrid Red Head.

After Hybrid Red Head and Red Storage 4044, Meteor significantly out yielded Mammoth Red Rock and Red Danish, but not Storage Red. There was no significant difference between the remaining varieties either in yield or weight per head.

On the basis of these data Red Storage 4044 followed by Hybrid Red Head would be the recommended varieties to grow.

Sweet Corn A field scale planting of five varieties of Sweet Corn was undertaken to compare relative maturities and yields.

Variety	Yield Dozen Cobs/Hectare
Sunnyvee	256 dz/ha
Golden Beauty	344 dz/ha
Aztec	522 dz/ha
XP2500	181 dz/ha
Calico	84 dz/ha

Sunnyvee was a week to ten days earlier than Golden Beauty while Golden Beauty and Aztec were in the same season. Golden Beauty appeared to be three to five days earlier than Aztec. XP2500 was about ten days later than Aztec and Calico was about a week later than Aztec. Both XP2500 and Calico received some frost damage.

In terms of yield Aztec appeared to out perform Golden Beauty. The difference may have been distorted somewhat in that only one-half acre of Aztec was planted and the much larger field of Golden Beauty did have some areas of poor production due to weeds and salinity. Preliminary results, however, would seem to warrant an increase in the acreage planted to Aztec.

Sunnyvee did not yield as well, but its continued production is warranted on a limited scale since it permits much earlier marketing than either Golden Beauty or Aztec. Cobs generally are shorter than Golden Beauty or Aztec, but still of acceptable quality.

Although XP2500 suffered from frost damage on the outer leaves it did without doubt produce the largest and most attractive cob. Limited production would be warranted in areas with a longer growing season for late market and where the risks of an early frost are fully recognized. Calico would appear to have limited potential as a result of its late maturity although its quality is certainly more than acceptable.

IMPACT

Basis 1973-77 unload data

	Total 5 year Average "in-season" Unloads '000 lbs	Sask. 5 year Average Unloads '000 lbs	Potential '000 lbs
Broccoli	74	0	74
Tomato	1129	1	1128
Cantaloupe	457	0	457
Watermelon	324	0	324
Cauliflower	228	57	171
Cabbage	3768	948	2820
Sweet Corn	389	122	267

RUMINANTS

THE INTENSIFICATION OF SHEEP PRODUCTION IN THE PRAIRIE ENVIRONMENT

N.C. RAWLINGS, I.A. Jeffcoate, W.E. Howell

ABSTRACT

The objective of this project is to develop and demonstrate management schemes, involving reproductive manipulation, to remove the seasonality and to improve the productivity of sheep production. The duration of the breeding season (time from when 80% of ewes first showed estrus to when 80% were anestrus) was 126 days for Suffolk ewes, 154 for Columbia, 157 for Rambouillet, 217 for Finn x Columbia ewes and 210 for Rambouillet, x Finn ewes. During the breeding season all five breed types responded as well to estrous synchronization using progestin containing intravaginal spounges. The use of Pregnant Mares' Serum Gonadotropin (500 units) (P.M.S.G.), given on the day of sponge removal, did not improve fertility, but did improve the synchrony of breeding. The Finn cross ewes produced more lambs per ewe. Out of season the success of estrous synchronization using P.M.S.G. and progestin containing intravaginal sponges was lower in ewes bred under natural daylight, but ewes bred after daylength manipulation (ewes were exposed to 18 hours of light for 30 days in January, then light was decreased 30 minutes per week until breeding in early May) responded almost as well as ewes bred during the breeding season. Hormone changes during estrous synchronization were also studied and at present a 5-year scheme is in place to study the economics of year round lamb production.

BACKGROUND AND OBJECTIVES

The ewe is seasonally polyestrus, breeding in the fall under decreasing daylength, lambing in late winter, with an anestrus period of variable length, but encompassing spring and summer in most breeds. Sheep production is not a major contributor to the animal industry because the seasonality of lambing and low productivity lower profitability and hamper orderly marketing. Although the problems of the sheep industry are many and complex there is the potential for increased output through manipulating reproduction. Intravaginal sponges impregnated with progestogens, or synthetic progesterone like substances, have been used with some success to synchronize estrus in ewes during the breeding season and to induce estrus in seasonally anestrus ewes. Generally fertility is poor during anestrus and treatment with Pregnant Mares' Serum Gonadotropin at sponge removal is required to induce estrus and ensure reasonable fertility. The use of P.M.S.G. to improve fertility during the breeding season has yielded varying results. It has been shown that fertility following synchronized estrus during anestrus can be improved by subjecting ewes to photoperiod manipulation. Reproductive manipulation has seen only limited commercial application, because

available information often stems from institutional flocks. The purpose of the present study was to demonstrate the efficiency of several techniques for reproductive management in sheep, under conditions as close to local commercial conditions as possible and utilizing breeds of sheep commonly used as base stock on the Prairies.

EXPERIMENTAL METHOD

One-hundred and seventy ewes were available, including grade purebred Columbia, Rambouillet and Suffolk ewes and half crosses of the Finnish breed with either the Columbia or Rambouillet breeds. The Finn sheep is noted for prolificacy and a long breeding season. Breeds with a limited seasonal anestrus generally do not show as large a seasonal fluctuation in fertility following synchronized estrus. The ewe flock was run with vasectomized rams fitted with colour marker crayons. During the period July to October 1981 and late January to April 1982 the crayon colour was changed every 14 days and the ewes checked for colour marks twice weekly to establish the length of the breeding season for the five breeds or breed crosses.

During October of 1981 60 ewes were treated for 12 days with intravaginal sponges containing 50 mg of medroxprogesterone acetate. At sponge removal half of the ewes received 500 I.U. P.M.S.G. I.M. in sterile water. All ewes were joined with fertile rams fitted with colour marker harnesses, 24 hours later at a ratio of 10 to 1. Ewes were checked for colour marks every 12 hours for five days. The crayon colour was changed after 14 days and open ewes were allowed one perod of rebreeding.

In late April, 1982 estrus was induced in 110 ewes using the same techniques except that all ewes received P.M.S.G. and two periods or cycles of rebreeding were allowed following the induced estrus. Sixty of these ewes were exposed to natural daylight conditions and 50 and all the rams used were exposed to photoperiod manipulation. This consisted of 16 hours of light daily, during January, decreasing subsequently by 30 minutes per week until breeding was completed in early May. Photoperiod controlled ewes were confined from 1600 to 800 daily in a pole barn roughly light proofed with black plastic and wooden shuttering. Additional light was provided by 200 Watt incondescent lights controlled by a timer. Light intensity at ewe head height varied from 150 lux below the lights to 50 lux at the most distant points.

RESULTS AND DISCUSSION

Table 1 shows the dates of the first and last recorded estrus for one breeding season for the 5 breeds or breed crosses studied. Also shown are the dates by which 80% of the ewes in the breed groups had shown a first estrus and become anestrus. These dates were used to calculate comparative breeding season and only one Suffolk ewe was observed in estrus when observations resumed in late January. The breeding season was longer for the Columbia and Rambouillet ewes, but longer again for the Finn half crosses with these breeds.

Table 1. The breeding season in five sheep breeds or breed crosses as indicated by the dates of first and last estrus in the group of ewes studied and the dates when 80% of the ewes had started or ceased showing estrus.

Breed	First Estrus	Last Estrus	80% Showing Estrus	80% Anestrus	Duration of Breeding Season[1] (days)
Columbia	Aug. 18	Mar. 12	Sept. 6	Feb. 7	154
Rambouillet	Aug. 7	Mar. 23	Sept. 6	Feb. 10	157
Suffolk	Aug. 19	Feb. 2	Sept. 28	before Feb. 1[2]	<126
Col x Fin	Aug. 11	Apr. 9	Aug. 22	Mar. 27	217
Ramb x Fin	Aug. 7	Apr. 6	Aug. 19	Mar. 17	210

[1]Based on dates when 80% of ewes showed first estrus or became anestrus.
[2]Only one Suffolk ewe showed estrus after January 29, when estrus resumed.

Table 2 shows the cumulative occurrence of estrus following removal of intravaginal sponges in the fall. There did not appear to be any breed effects, but the P.M.S.G. treated ewes appeared to show earlier and better synchronized estrus. Table 3 shows the same information for ewes bred in early May during mid anestrus. All ewes received P.M.S.G., but in this case half of the ewe were bred under conditions of natural daylight and half after photoperiod manipulation. Photoperiod manipulation appeared to improve the synchrony of estrus.

Table 2. The cumulative percentage of ewes in estrus at different times following withdrawal of progestin containing sponges with or without P.M.S.G. administration in ewes bred in the fall.

Hours From Sponge Removal	P.M.S.G. Breed C[1]	R	S	CxF	RxF	P.M.S.G. Breed C	R	S	CxF	RxF
36	67	100	50	33	50	33	33	50	17	0
48	100	83	50	100	100	83	83	50	83	83
60	-	100	67	-	-	100	100	100	100	100
>72	-	-	100	-	-	-	-	-	-	-

[1]C:Columbia, R:Rambouillet, S:Suffolk, CxF:Col x Fin, RxF:Ramb x Finn.

Table 3. The cumulative percentage of ewes in estrus at different times following withdrawal of progestin containing sponges and P.M.S.G. administration in ewes bred in the spring under natural daylight conditions or after photoperiod manipulation.

Hours From Sponge Removal	Photoperiod Manipulated Breed					Natural Daylight Breed				
	C[1]	R	S	CxF	RxF	C	R	S	CxF	RxF
36	50	70	60	90	70	75	50	50	67	42
48	60	70	70	90	70	92	50	58	83	67
60	80	90	-	100	90	100	83	75	92	83
>72	90	-	-	-	-	-	-	92	-	-

[1]C:Columbia, R:Rambouillet, S:Suffolk, CxF:Col x Finn, RxF:Ramb x Finn.

Gestation lengths shown in Table 4 were not effected by treatment, but appeared to be shorter for spring bred ewes. The expected breed differences were also seen, with the Suffolk ewes having the shortest gestation, Columbia and Ramboiullet longest and the Finn crosses intermediate.

Table 4. Gestation lengths (days) for ewes of 5 different breeds or breed crosses after synchronized breeding in the fall or spring.

BREED	FALL BRED	SPRING BRED
Columbia	148 $\pm$ 0.4[1]	146 $\pm$ 0.4
Rambouillet	149 $\pm$ 0.5	147 $\pm$ 0.7
Suffolk	145 $\pm$ 0.7	145 $\pm$ 0.5
Col x Finn	147 $\pm$ 0.5	145 $\pm$ 0.4
Ram x Finn	147 $\pm$ 0.6	145 $\pm$ 0.5

[1] $\bar{x} \pm$ SE

The percentage of ewes that lambed following breedings at the synchronized estrus and one follow up estrus period during October are shown in Table 5. A_0 is ewes not treated with P.M.S.G., A_1 with P.M.S.G., results for these two groups did not differ. Group B was the group of ewes bred in spring under natural daylight, C, ewes bred after photoperiod manipulation. All spring bred ewes were bred at the synchronized estrus and two follow up periods of estrus. Clearly ewes bred under natural daylight faired worst than those induced to recycle by photoperiod manipulation. Under natural daylight the purebreds especially the Suffolks performed less well than the Finn cross ewes.

Table 5. The percentage of ewes that lambed following estrus synchronization with progestin containing intravaginal sponges with (A_1BC) or without (A_0) P.M.S.G. and bred under natural daylight conditions in October (A_0A_1) and April (B) or bred in April after photoperiod manipulation (C).

Breed	A_0	A_1	B	C
Columbia	100	83	50	90
Rambouillet	83	100	25	90
Suffolk	100	100	8	80
Col x Finn	100	100	83	80
Ramb x Finn	100	100	67	80

P.M.S.G., results for these two groups did not differ. Group B was the group of ewes bred ins pring under natural daylight, C, ewes bred after photoperiod manipulation. All spring bred ewes were bred at the synchronized esrus and two follow up periods of estrus. Clearly ewes bred under natural daylight faired worst than those induced to recycle by photoperiod manipulation. Under natural daylight the purebreds especially the Suffolks performed less well than the Finn cross ewes.

Table 6 shows lambing percentages or lambs born per 100 ewes treated. The P.M.S.G. treatment did not consistently elevate lambing percentages in fall bred synchronized ewes. In spring bred ewes lambing percentages reflected the differences in the number of ewes conceiving and lambing shown in Table 5. Based on ewes lambing, no obvious differences were noted between ewes bred under natural daylight or after photoperiod manipulation. Generally, the effects of the elevated prolificacy of the Finn sheep is shown in the half Finn crosses used in this study.

Table 6. The lambing percentage (lambs born per 100 ewes treated) for ewes lambing following estrus synchronization with progestin containing intravaginal sponges with (A_1 B C) or without (A_0) P.M.S.G. and bred under natural daylight conditions in October (A_0 A_1) and April (B) or bred in April after photoperiod manipulation (C).

Breed	A_0	A_1	B	C
Columbia	183	117	100	90
Rambouillet	117	150	45	150
Suffolk	150	140	8	110
Col x Finn	200	283	192	180
Ramb x Finn	183	233	170	180

IMPACT

In conclusion, all of the breeds studied responded well to estrus synchronization during the breeding season. Out of season, photoperiod manipulation improved the response to synchronized estrus in all breeds. The prolifacacy of the Finn cross ewes, their long breeding season and hence consistently good response to controlled breeding irrespective of photoperiod manipulation, make them an ideal choice for intensified production schemes, aimed at year round lamb production. Based on these studies, a 5 year scheme is now in place to study the economics of year round lamb production and a series of seminars and articles are being prepared to promote the application of these techniques commercially. The ability to improve fertility and produce lambs year round could dramatically improve productivity and orderly marketing in the fat lamb production industry.

A STUDY OF THE EFFECT OF B-CAROTENE ON REPRODUCTION IN CATTLE

F. Bristol

ABSTRACT

Three dairy herds with poor reproductive performance and marginally low (less than 300 ug/100 ml) plasma B-carotene levels were used in this experiment. Thirty cows in each herd were randomly divided into 2 groups shortly after parturition. One group was fed a supplement containing 200 mg of B-carotene per day while the other group was given a supplement without B-carotene. The supplements were fed for 100 days after parturition.

In these three herds the plasma B-carotene levels did not reach low levels until January and preliminary data indicated that supplementation with B-carotene at the rate of 200 mg/day will increase the plasma levels to 450 ug/100 ml. The effect of this supplementation on reproductive performance has not been analyzed as the experiment is still in progress.

EXPERIMENTAL METHOD

In order to study the effect of B-carotene supplementation on fertility in dairy cows, 10 herds with poor reproductive performance were evaluated to determine their plasma B-carotene status. Three dairy herds which had minimal plasma B-carotene levels (< 350 ug/100 ml) were selected for this study. The reproductive performance of these three herds at the

beginning of the trial is shown in Table 1. Thirty recently calved cows in each herd were randomly divided into 2 groups. One group was supplemented with 200 mg B-carotene mixed with an inert carrier per day and the other was given an equal quantity of the carrier. The two supplements were formulated so that they appeared the same and owners of the herds were not informed which supplement contained the B-carotene . The cows were given the supplement for 100 days after parturition. Blood samples were collected once a month to monitor plasma B-carotene levels and the reproductive records are being analyzed to compare the reproductive performance of the 2 groups of cows.

RESULTS AND DISCUSSION

The results of this study confirm those of a previous study showing that forages used in Saskatchewan (brome hay, alfalfa hay and cereal silage) can maintain high plasma B-carotene levels except in a few instances during the winter months when they become marginally low (Table 1). The supplementation trial was not commenced until January as the mean plasma levels of the selected herds did not drop into the low category (< 350 ug/100 ml) until that time. The mean plasma levels of B-carotene after one month of supplementation are shown in Table 2. In all herds there was a marked increase of the mean plasma levels of B-carotene in the supplemented cows. This trial is continuing at the present time and will be completed at the end of May, 1983 when the reproductive data can be analyzed and compared to determine the effect of B-carotene on reproductive performance.

Preliminary observations from this and previous studies indicate that most forages fed to dairy cows in the Saskatoon area will maintain adequate plasma levels of B-carotene and that in a few instances B-carotene may have to be supplemented during the winter months.

Table 1: Mean Plasma B-Carotene (ug/100 ml) in Three Dairy Herds After Supplementation for 1 Month

Farm	Mean Plasma B-Carotene before supplementation	Mean Plasma B-Carotene Supplement with B-Carotene	Supplement without B-Carotene
A	346.4	450.1	324.7
B	325.9	473.0	298.4
C	288.3	503.9	292.6

Table 2: Reproductive Performance and Mean Plasma B-Carotene Level in Three Dairy Herds Prior to Supplementation

	Farm		
	A	B	C
Type of Forage	brome/alfalfa hay	alfalfa hay	cereal silage
Mena Plasma B-Carotene (g/100 ml)	346.4	325.9	288.3
Calving to Conception (days)	126.5	148.4	132.6
Cows Showing estrus within 60 days of parturition (%)	21.3	41.6	40.4
First Service conception rate (%)	46.4	39.3	42.5
Services per Conception	2.1	2.5	2.3

THE EVALUATION OF THE EFFECTS OF SULFATES AND OTHER ELEMENTS IN DRINKING WATER ON TRACE MINERAL REQUIREMENTS OF CATTLE

C.M. Williams, M.E. Smart, D.A. Christensen, R.D.H. Cohen

ABSTRACT

A farm scale water treatment plant has been installed which removes sulfates and other salts from the drinking water of cattle by reverse osmosis. Pregnant Hereford cows and heifers were divided into four groups:

1) Cows receiving untreated drinking water.
2) Cows receiving treated drinking water.
3) Heifers receiving untreated drinking water.
4) Heifers receiving treated drinking water.

All cattle received a mineral supplement which provided 10 mg Cu/kg dietary dry matter.

Blood and liver biopsy samples were collected in fall when cattle came off pasture, at calving and in spring immediately before cows and calves were turned out to pasture.

Reverse osmosis treatment of drinking water significantly increased the copper status of cows determined from copper levels in liver biopsy samples ($P < 0.05$).

BACKGROUND AND OBJECTIVES

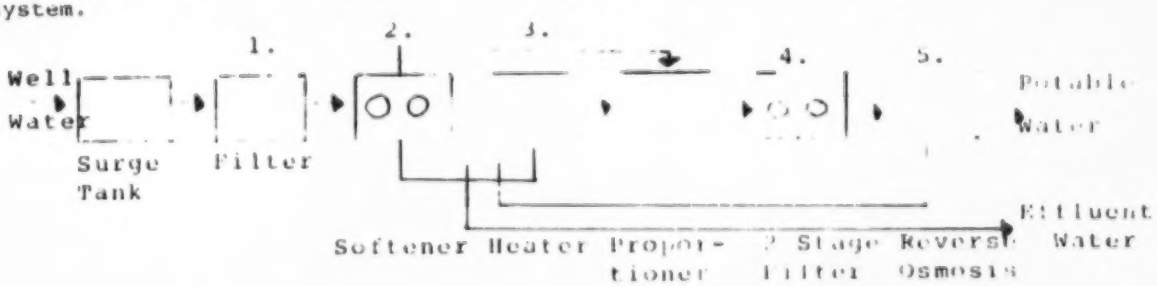
I. Introduction

The study of water quality in conjunction with the trace element status of beef cattle was initiated because it was hypothesized that there would be an interaction between the sulfates in the water, and the trace elements in the feed. This possibility gained support in some early analysis which revealed a marked rise in plasma copper when the cows were drinking surface water and a drop when they were offered water from deep aquifers (60 meters or below). Such waters, which carry 2000 ppm or more of dissolved salts, have been observed to lead to severe diarrhea and even death with young poultry, swine and ruminants. These symptoms closely resemble those described for copper deficient cattle such as reduced fertility in cows and semen quality in bulls, poor hair coat, diarrhea, reduced growth rate, sudden death, inability to suckle, incoordination, stiff gait, opisthotonus or lateral recumbancy in newborn and young calves.

A farm scale reverse osmosis water treatment plant has been installed which removes sulfates and other dissolved salts from deep aquifer drinking water.

II. The System

The accompanying diagram indicates the parts of the water purification system now in place. Although all the components are available commercially there must be a careful matching to ensure a working system.



Water Purification System: (the critical sequence is: 1) remove iron salts, 2) exchange Na for Ca, 3) heat the water, 4) remove the particulate matter, 5) concentrate the $Na_2 SO_4$ in the effluent water).

III. Objectives

There are three objectives, each being studied in separate stages during this project:

1) To install a farm scale water treatment plant which will produce 800 gallons of water per day at a constant purity of 150 ppm of dissolved salts.
2) To determine the effect of the removal of sulfate salts from the drinking water on the copper status of pregnant beef cows and their calves.
3) To determine the effects of the removal of sulfate salts from the drinking water on the productivity of beef cows and calves (liveweight, fertility, calf viability, etc.).

EXPERIMENTAL METHOD

Stage 1 (Objective 1) of the project was completed in 1981-82 and the system has been briefly described in the Introduction to this report.

Stage 2 of the project was commenced in fall 1982 when cows were removed from the pasture following weaning. Pregnant Hereford cows and heifers were divided into four groups:

1) Cows receiving untreated drinking water.
2) Cows receiving treated drinking water.
3) Heifers receiving untreated drinking water.
4) Heifers receiving treated drinking water.

All cattle received a mineral supplement which provided 10 mg Cu/kg dietary dry matter (NRC recommended requirements). Blood and liver biopsy samples were collected in fall when cattle came off pasture, at calving and in spring immediately before cows and calves were turned out to pasture.

RESULTS AND DISCUSSION

Only the results of the pre-calving liver biopsy are available due to unavoidable delays in laboratory analyses. The levels of copper in the liver of cattle drinking the treated water were significantly greater ($P < 0.05$) than those of cattle drinking untreated water (Table 1).

Table 1. The effect of water treatment on pre-calving liver copper (u mol g^{-1} DM) levels in beef cattle.

Cows		Heifers	
Untreated Water	Treated Water	Untreated Water	Treated Water
0.10 $\pm$ 0.001	0.18 $\pm$ 0.01	0.11 $\pm$ 0.001	0.20 $\pm$ 0.008

The pre-calving copper status of cattle was considered to be the most important analysis to obtain in the first instance. Laboratory analyses from other sample collection times is proceeding.

Table 1 indicates that, although removal of sulfates from the water almost doubled the amount of copper stored in the liver, the copper status of cows drinking treated water is still only in the low-marginal range, despite a copper supplement which should have provided sufficient copper to meet their requirements. Reasons for this result will continue to be investigated. Liver copper levels of cattle drinking untreated water indicate that these cows were copper deficient despite adequate dietary copper levels, suggesting an interaction between sulfates and copper nutrition of cattle.

Samples of treated and untreated water were collected and analyzed to monitor the effectiveness of the treatment process. These data are presented in Table 2.

Table 2. The effect of reverse osmosis on the concentration of dissolved salts (ug g^{-1}) in deep aquifer drinking water for cattle.

Constituent	Untreated Water	Treated Water
CO_3	NIL	NIL
Ca	207	3.1
Cl	39	144
HCO_3	484	112
K	8.0	0.4
Mg	142	< 1
Na	440	197
OH	NIL	NIL
SO_4	1580	162

These data indicate reasonable quality control but suggest that the quality level of 150 ppm total dissolved salts which was achieved in the first year of operation may not be sustainable over two years of operation.

IMPACT

This project is developing new equipment and testing results following its use and further research is required before the impact of the research on Agriculture in Saskatchewan can be assessed.

IMPROVEMENT OF PROVINCIAL SHEEP FLOCK (INVESTIGATION OF TECHNIQUES LIKE A.I. AND EMBRYO TRANSFER)

G. Tosh, D. Donald, J. Nohachowsky
(N.C. Rawlings, N. Savage, R. Mapletoft)

ABSTRACT

This project sought to establish the techniques of artificial insemination and embryo transfer in our research programme and to evaluate their usefulness for the prairie sheep industry. A useful

technique has been established for collecting ram semen on farm and application of A.I. in estrous synchronized ewes is in progress. Twelve ewes were superovulated after estrus synchronization using progestin containing intravaginal sponges. Six ewes received 1,100 units of pregnant mares serum gonadotropin (P.M.S.G.) 24 hours before sponge removal and 6 a graded dose of Follicle Stimulating hormone from pig pituitaries (FSH-P) starting at the same time. The FSH-P injections were given every 12 hours, two injections of 5 mg, two of 4 mg and two of 3 mg. Ewes were bred and blood sampled around estrus for hormone analysis. Eggs were flushed from ewes 6 days after estrus. Six recipient ewes receiving 12 viable fertilized eggs 6 days after estrus were pregnant at day 20. Ovulation rates were good in both sets of donor ewes, but both treatments produced variable results (3 to 8 corpora lutea in P.M.S.G. treated ewes with 1 to 4 unovulated follicle, 1 to 17 corpora lutea in FSH-P treated ewes with 1 to 5 unovulated follicles). Egg recoveries after flushing the upper half of the uterine horn were variable, and very low if only the upper third of the horn was flushed.

BACKGROUND AND OBJECTIVES

Artificial insemination has been utilized in sheep breeding with some success. Insemination with fresh semen at a relatively low dilution has been used, but the success with semen extended, frozen and thawed has been poor. Little widespread application of A.I. has been seen in sheep breeding programmes except for some areas in Europe and Australia. In controlled breeding programmes A.I. at fixed times after estrus synchronizing treatments has produced good fertility. Artificial inseminations could be used as in cattle to speed genetic improvement and control disease spread. In addition, as ram fertility varies with season, semen collection, evaluation and utilization at an optimum concentration and quality by A.I. could help to partly alleviate seasonal variation in fertility in year round lambing programmes. The present project was designed to demonstrate the efficacy of A.I. in controlled breeding programmes and to examine its economic usefulness.

Embryo transfer has seen widespread use in cattle breeding programmes, largely to proliferate exceptional genetic material and in exportation and importation of valuable and new genetic potential. The earliest attempts at embryo transfer were performed in sheep, but this tool has not seen much application at all in sheep breeding and improvement programmes. The procedure involves surgical procedures in the ewe and the cost of the procedures could be prohibitive. The purpose of the present project was to cost out the procedures and to examine various techniques for superovulating the ewes.

EXPERIMENTAL METHOD

Initially it was planned to develop a simple procedure for collecting semen from rams and for evaluating and preparing it for A.I. on the farm. A simple restraining stand was made to immobilize a teaser ewe. Ewes at

any reproductive stage could then be used as teasers. A simple artificial vagina was constructed using 2" A.B.S. piping. a latex liner and glass collecting tube. The A.V. was filled (between liner and casing) with hot water (45°C) and the rams penis deflected into the A.V. as he mounted the immobilized teaser ewe. Semen was immediately evaluated by standard (American College of Theriogenology) procedures. This approach is now being utilized to collect semen for routine evaluation, the testing of extenders, and the preparation of extended semen for use in estrous synchronized ewes.

During the breeding season estrus was synchronized in 12 crossbred ewes using progestin containing intravaginal sponges (Repromap, Tucco) in place for 12 days. Six ewes were treated with 1,100 units of P.M.S.G. (IM) 24 hours before sponge removal to produce superovulation (increased ovulation rate). Six ewes received FSH-P (IM) every 12 hours starting 24 hours before sponge removal. The first two injections were of 5 mg each, the second two of 4 mg each and the first two 3 mg each. Rams were introduced 24 hours after sponge removal at a ratio of 1 ram to 4 ewes. Rams of proven fertility were used and were rotated from pen to pen every 12 hours. Embryo collection was attempted 6 days after estrus. Blood samples were collected from the ewes (jugular veni puncture) every 6 hours from 24 hours before sponge removal to 24 hours after estrus was first detected for hormonal analysis.

Embryos were collected under halothane anaesthesia after induction with a short acting barbiturate. The reproductive tract was exteriorized through a mid ventral incision just anterior of the mammary gland. Eggs were flushed from the upper half of the uterine horn through a sterile flanged catheter placed in the oviduct and collected in a petri dish. Two flushings of 10 to 15 mls of a modified Dulbecos medium were used, using a syringe and blunted 18 g needle. Eggs were counted and evaluated, as were ovarian structures. Viable eggs were transferred to 6 recipient ewes (2 per ewe, one in each horn), using small plastic catheters introduced into the uterine horn through a needle puncture incision. Recipient ewes were pregnancy tested 20 days later using a serum progesterone analysis and then aborted with prostaglandin F_{2a}.

RESULTS AND DISCUSSION

As indicated above the A.I. studies have progressed to the point of establishing semen collection procedures and work on extenders and aplication of A.I. in our continuing controlled breeding trials is in progress.

The results of the trial of two superovulatory regimes in the ewe are shown in Table 1. The FSH-P treatment appeared to produce more corpora lutea. The ovulation rate apeared to be good for both treatments, but the results are quite variable. The inherrent variability of superovulation with P.M.S.G. was not circumvented by the FSH-P treatment.

Twelve viable fertilized eggs were transferred to 6 recipients at day 6 after estrus and all were pregnant at day 20. Clearly the egg recovery rate is variable and all but one egg was missed when flushing was restricted to the upper third of the uterine horn at day 6 after estrus. Flushing of almost the whole horn is necessary, perhaps using a catheter inserted in the uterine horn, to obviate the problem of resistance to flow found in flushing back through the oviduct. Several donor ewes were relaparotomized after several months and revealed little or no adhesions in the area of the original incision, or reproductive tract. Careful technique could therefore allow a ewe to serve as a donor on several occasions. Further trials will be performed to improve egg recoveries and determine an average rate of recovery of viable fertilized eggs to allow a realistic costing of the procedure. Hormonal analysis is in progress.

Table 1. Ovarian response and numbers of eggs recovered at day 6 after estrus following superovulation of ewes with P.M.S.G. or FSH-P.

EWE	TREATMENT	OVARIAN STRUCTURES AT DAY 6		EGGS RECOVERED
		CORPORA LUTEA	FOLLICLES(>5mm dia)	
360	P.M.S.G.	3	4	2
451		6	-	5
389		8	1	4
378		8	1	2
422*		4	1	-
425*		3	2	-
370	FSH-P	13	1	8
414		9	3	6
413		1	5	1
361		11	-	6
433*		17	1	1
436*		11	-	-

*flushed upper third of uterine horn only.

IMPACT

Although A.I. and embryo transfer techniques are used in sheep, widespread application has not occurred. Artificial insemination could play a role in controlled breeding programs and could be as valuable to the sheep industry as it has been to the cattle industry in terms of genetic improvement. Embryo transfer techniques offer an opportunity to conveniently introduce new genetic material and proliferate it rapidly. The present project seeks to establish these techniques in our research programme and to evaluate their usefulness for the prairie sheep industry.

EMBRYO TRANSFER IN THE COW: EFFECTS OF PMSG AND FSH ON SUPEROVULATORY RESPONSE, OVA RECOVERED, OVA FERTILIZED AND ENDOCRINOLOGY

Reuben J. Mapletoft

ABSTRACT

A study was designed to compare the use of pregnant mares serum gonadotropin (PMSG) and follicle stimulating hormone (FSH) in a superovulatory program with the overall objective of improving the utilization of bovine embryo transfer.

Thirty Simmental cross cows were treated on day 10±2 of their cycle with a single injection of 2250 I.U. of PMSG or twice daily treatments of decreasing doses of FSHP for five days (total dose 30 mg). Seventy-two hours after initiation of treatment, cows received a luteolytic dose of prostaglandin F2a (cloprostenol). At heat (on day 6 of treatment), cows were bred naturally at least twice with a fertility tested Angus bull. Embryos were collected nonsurgically seven days after the onset of heat and were classified as fertilized or not fertilized, and if so, whether they were degenerate. Blood samples were collected daily and were assayed for prostesterone, estradiol and luteinizing hormone.

There were no significant differences between PMSG treatment and FSH treatment in numbers of ovulations (15.5 vs. 13.2); total ova recovered (8.1 vs 8.6); fertilized ova (3.0 vs 4.8); fertilization rate (37% vs 56%); transferrable ova (2.7 vs 4.8); recovery rate (53% vs 65%); or interval from cloprostenol to heat (55 hr. vs 50 hr.). However, there were nearly two more transferrable ova per cow in the FSH group. Similarly, nearly 15% more ova were recovered in the FSH group. Although hormone perameters did not provide any particular insight into differences in response, hormone abnormalities may have contributed to the apparent problems associated with PMSG treatment.

BACKGROUND AND OBJECTIVES

One of the most consistent problems associated with the successful utilization of embryo transfer is the inconsistency of superovulation results. Although each cow on the average produces five to six viable, transferrable ova, some produce 30 or more, while others produce none. Precise, effective studies are needed to increase on a more consistent basis the numbers of viable transferrable ova produced by each donor cow.

Basically, most superovulatory schemes involve the administration of compounds with follicle stimulating properties eg. pregnant mares serum

(PMSG) and pituitary extracts (FSHP). However, both approaches have their own shortcomings.
Knowledge in the area of endocrinology of superovulation is still incomplete and most studies have been with PMSG. There is very little critical comparitive data between FSHP and PMSG. Therefore, a study was designed to compare PMSG and FSHP in a superovulatory regime and to establish an endocrinologic baseline for these two treatments.

EXPERIMENTAL METHODS

Thirty Simmental-cross cows were randomized into one of two treatment groups (15 cows each) on day 10±2 of their cycle. Cows in group I received a single intramuscular injection of 2250 I.U. of PMSG. Cows in group II received twice daily treatments of decreasing doses of FSHP i.e. 5, 4, 3, 2, 1 mg. Bid for 5 days (total dose 30 mg). Seventy-two hours after initiation of superovulation treatment, cows received 500 ug cloprostenol (PGF2a). At heat (on day 6), cows were bred naturally at least twice with a fertility tested Angus bull. Seven days later embryos were collected by a non-surgical technique using a Rausch catheter and an interrupted syringe technique. Corpora lutea (CL) were counted at least twice by two veterinarians and a consensus was reached as to CL counts. Embryos were flushed from the cow using Dulbeccos phosphate buffered saline (PBS) and 2% fetal calf serum. Embryos were searched for using a steroscopic microscope and when found, were placed in PBS containing 20% fetal calf serum. Ova were classified as fertilized or non-fertilized and whether embryos were degenerate. Finally, the number of transferrable ova for each cow was counted.

Blood samples were collected daily at 8 a.m. for serum progesterone (P4) levels and four times daily beginning at 8 a.m. on day 5 and ending at 8 a.m. on day 7 for serum luteunizing hormone (LH) and estradiol (E2). Serum hormone levels were determined by a specific radioimmunoassay.

Endpoints included (1) ovarian responses (CL and unovulated follicles); (2) serum hormone levels; (3) embryo recovery rate, and (4) embryo quality scores. Data were analyzed by analyses of variance and means were compared using a multiple range test. Furthermore, attempts were made to correlate specific hormone levels with ovarian response in individual cows.

RESULTS AND DISCUSSION

Two of the 30 cows treated did not show heat and were not considered in the analysis. It is interesting that both cows had been treated with PMSG. One cow in the FSHP group had less than two CL and was also removed from analysis. Therefore, 90% of cows (13 PMSG and 14 FSHP) were considered responsive and were considered in the analysis.

There was no significant differences between group I PMSG cows and group II FSHP cows in ovarian response (CL count), ova recovered, fertilized

ova and transferrable ova (Table I). However, numbers of fertilized ova and transferrable ova tended to favor the FSHP group. It may be hypothesized that the endocrine environment in the PMSG group did not favor fertilization and/or normal embryo development in spite of a similar ovulation rate. This is further supported by the fact that there were six degenerate eggs in the PMSG group and no degenerate eggs in the FSHP group. There were two more transferrable embryos in the FSHP group than in the PMSG group.

The overall average interval from PGF2a injection to heat was 52.4 $\pm$ 2.8 hr. and was not different between the PMSG group (55.1 $\pm$ 4.6 hr.) and the FSHP group (50 $\pm$ 3.3 hr.). There was no relationship between interval to estrus and CL count. However, 19 (63.3%) of the cows representing 391 CL (78.5%) were in heat by 48 hr. after PGF2a treatment.

Relationships between the various end-points and serum hormone levels were difficult to demonstrate. Generally, serum P4 increased after initiation of treatment on D.10 (especially in PMSG group) and dropped to less than 1 mg/ml by 24 hr. after PGF2a treatment. Serum P4 levels were seen to begin rising by D.2 after estrus and were very high by D.7 at collection. Serum E2 levels were generally higher in the PMSG group than in the FSHP group. This was especially true from D.3 to D.6 after estrus and may account for embryo degeneration in this group. Serum LH peaks were detected within 24 hr. of estrus in 11/15 of the PMSG treated cows and in 14/15 of the FSHP treated cows. This could suggest that a relative asymchronous LH peak in the PMSG cows could result in a asychronous ovulation timing and thus a reduced fertilization rate.

There was a significant positive correlation between CL count and total ova and serum E2 level three days before estrus in FSHP treated cows and two days before estrus in PMSG treated cows. This simply indicates the number of developing follicles. A number of other significant correlations do not make biological sense and must await further investigation. Negative correlations of embryo quality and serum E2 level may support the idea that superovulation as an abnormal phenomenon could adversely affect the environment of the female reproductive tract.

IMPACT

Based on the results of this experiment, it is difficult to arrive at any firm conclusions regarding either treatment. However, two additional transferrable ova in the FSHP treatment group does tend to support this method in a superovulation scheme. Furthermore, serum hormone levels do tend to explain the relatively poorer embryo quality in the PMSG group. Obviously, these endocrine data will provide a sound basis for future work in which we may be able to explain why certain cows respond while others do not.

Table 1. Comparison of Ovarian Response, Ova Recovered and Embryo Quality.

	n*	CL count**	Ova		
			Recovered	Fertilized	Transferrable
Group I PMSG	13	15.5 ±1.7	8.1 ±1.5	3.0 ±.8	2.7*** ±.7
Group II FSHP	14	13.2 ±1.4	8.6 ±1.8	4.8 ±1.2	4.8 ±1.2

* Non-responsive cows (2 in group I and one in group II) were not included in analysis.

** CL count based on rectal palpation.

*** A difference of two transferrable ova is not statistically significant.

STUDIES ON SELENIUM STATUS IN WINTERING BEEF CATTLE: A PRELIMINARY REPORT

B. Laarveld, M.E. Smart and D.A. Christensen

ABSTRACT

This study is nearing completion and the results presented are preliminary. Selenium status of the Termuende Farm cows appeared to be marginally adequate. There were some seasonal fluctuations in selenium status of the cows, but these were of little significance. Some of these changes might not only be seasonal, but could also be the result of lactation. We did not observe any differences in selenium status due to breed or diet. Removal of sulphates from drinking water by reverse osmosis did not improve selenium status. All calves showed low selenium status at birth, which improved to a marginal status at several months after birth. We suggest that the marginally adequate status of the cows was insufficient to promote normal selenium status in calves. High sulphate content of drinking water does not appear to have an effect on selenium status.

BACKGROUND AND OBJECTIVES

Information is required on the adequacy of selenium status of Saskatchewan beef cattle. Generally, cattle fed feeds grown on grey wooded soil (low selenium) have suspect selenium status. In addition, there is speculation that the high sulphate content of deep well drinking water may reduce the availability of selenium. The incidence of clinical selenium deficiency, with symptoms such as white muscle disease and sudden death, does not appear high. The incidence of marginal selenium deficiency, with effects such as impaired reproduction, poor growth, and

reduced disease resistance, is difficult to measure and potentially has great economic impact.

The objective of this study was to: 1. measure the selenium status of cows and calves at the Tremuende Farm; and 2. measure the effect of sulphate removal from drinking water on selenium status.

EXPERIMENTAL METHOD

This study was part of a major long-term study on mineral status of the beef herd at the University of Saskatchewan Termuende Farm in Lanigan. The major thrust of the long-term study is to find methods for improving copper status of this herd. Animals were fed a variety of rations containing high or low copper, different quality forages and ammoniated straw. In addition a group of animals had access to drinking water which was desulphated by reverse osmosis. The regular drinking water contained approximately 1300-2400 ppm sulphate, which is in excess of the maximum 'safe' level of 800 ppm. The animals used were of a mixture of breeds to determine whether certain breeds might be more susceptible to development of selenium deficiency.

Blood samples were obtained at weaning (October 9, 1981), sorting (December 9, 1981), calving, post-calving (May 4, 1982) and during the summer of 1982. The blood samples were collected by venipuncture in vacutainers specially designated for trace mineral analyses. Plasma was obtained by centrifugation and stored at -20°C until analyzed.

Plasma was analyzed for selenium by a graphite furnace atomic absorption method developed in this Department. At present approximately 20% of the analyses remain to be done.

RESULTS AND DISCUSSION

The data reported are preliminary only and should be interpreted with caution. The results of assessment of selenium status of both cows and calves and the effect of sulphate removal from drinking water are presented in Table 1. Since the data have not been analyzed statistically we are not able to present the breed and diet effects on selenium status.

Cows throughout the year appeared to have marginally adequate selenium status. An adequate selenium status is indicated by a plasma selenium concentration of 0.07-0.30 ppm, and a marginal status by 0.02-0.04 ppm. Mild fluctuations during the post-calving period and summer may be explained by a drain of selenium in milk. These fluctuations were relatively minor. Removal of sulphate from drinking water did not result in higher plasma selenium concentrations. Therefore sulphate content of drinking water should be of relatively little concern in relation to selenium status.

Calves born in both groups showed definite marginal selenium status with no apparent effect due to treatment of drinking water. The marginal selenium status of the calves may be a reflection of the marginally adequate status of the cows. It is of interest that plasma selenium in calves increased during the post-calving period, while that in cows declined. Thus milk probably was an important source of selenium for the calf.

IMPACT

The results of this study suggest that selenium status of the calves especially was inadequate. This may result in reduced growth and disease resistance. Further studies are required to establish the proper method and amount of selenium (and Vitamin E) supplementation to improve selenium status of the calves. High sulphate content of drinking water does not appear to have a major effect on selenium status.

Table 1. Plasma selenium (ppm) in wintering beef cows and their calves and the effect of sulphate removal from drinking water

	Untreated Water		Treated Water	
	Cows	Calves	Cows	Calves
Weaning bleed (October 9, 1981)	0.418± 0.0016[1] N = 48	-	0.0430± 0.0023 N = 23	-
Sorting bleed (December 9, 1981)	0.0473± 0.0013 N = 62	-	0.0473± 0.00151) N = 30	-
Calving	0.050± 0.0023 N = 32	0.0224± 0.001 N = 27	0.0464± 0.0032 N = 11	0.0213± 0.0011 N = 12
Post-calving 4 days (calves only)	-	0.0266+ 0.0016 N = 16	-	0.0263± 0.0038 N = 4
Post-calving May 4, 1982	0.0451± 0.0013 N = 46	0.0393± 0.0023 N = 21	0.0426± 0.0021 N = 25	0.0338± 0.0032 N = 12
Summer bleed	0.0532± 0.0019 N = 44	NA[2]	0.0491± 0.003 N = 22	NA

[1] Mean ± SE.
[2] Samples remain to be analyzed.

NON-RUMINANTS

THE INFLUENCE OF NUTRITIONAL DENSITY ON THE PRODUCTIVITY OF CHICKEN BROILERS

H.L. Classen, G.L. Campbell, R.K. McMillan and R.E. Salmon

ABSTRACT

A total of 5760 chicks were utilized in three trials designed to study the influence of feed ingredients on the performance of chicken broilers fed diets varying in nutrient density. Canola meal and raw faba beans included as 20% of the total diet were studied in trials one and two, respectively, while triticale was examined as a feed ingredient in trial three. Each test ingredient was included in five diets of varying nutrient density and compared to isonitrogenous and isocaloric diets formulated with wheat, barley, soybean meal and tallow as major ingredients. Reducing nutrient density decreased body weight at seven weeks of age, efficiency of feed utilization and carcass grades for fleshing and fat. Mortality due to acute or sudden death syndrome was slightly reduced by lower density feeding regimes while the incidence of leg problems was unaffected. The feed ingredients studies did not markedly influence the response of broilers to different dietary nutrient density. Productivity of broilers was affected by trial but the response to nutrient density changes remained similar.

BACKGROUND AND OBJECTIVES

Previous experiments in this study have revealed that in general, broiler productivity is reduced by the feeding of low nutrient density diets. Despite the negative influences on growth rate and feed conversion, under certain costs of feed ingredients, low nutrient density diets were economically superior in terms of feed ingredient costs per unit of low broiler weight. These results emphasized the importance of providing a model whereby a feed could be formulated to the most economical nutrient density based on feed ingredient costs and predicted broiler performance rather than a specific (normally high) nutrient density. To establish this model, data on the interactions of feed ingredients and dietary nutrient density are essential. This was demonstrated by the significant influences of such ingredients as tallow and corn in the initial year of this study. The objective of this year's research was to provide data on the influence of Canola meal, faba beans and triticale in diets varying in nutrient density.

EXPERIMENTAL METHODS

Three broiler trials were undertaken utilizing a total of 5760 broilers. In each trial 10 different dietary treatments were studied in a randomized block design. Four pens were assigned to each dietary treatment (2 pens of males and 2 pens of females). A starter diet was fed until four weeks of age and a finisher for the remainder of the

experimental period. Energy to protein ratios were 130 and 160 for the starter and finisher diets, respectively. The range of metabolizable energy (ME) levels for the starter and finisher diets was 2700 to 3100 and 2770 to 3180 Kcal/Kg, respectively. In trial 1 20% Canola meal was included in test diets while 20% raw faba beans were tested in trial 2. Triticale was the test ingredient in trial 3 and acted as a total replacement of the wheat used in the control diets.

Data were collected for body weight at 4, 6 and 7 weeks of age, feed consumption, incidence and cause of mortality and leg problems, and carcass grades for fleshing and fat.

RESULTS AND DISCUSSION

The influence of nutrient density and test dietary ingredients on broiler growth rate and efficiency of feed utilization are shown in tables 1 and 2. As previously reported both growth rate and the efficiency of feed utilizaiton are reduced with low nutrient density diets. The influence of dietary ingredients was small with test ingredient diets producing broiler performance equal to control fed broilers. In the case of raw faba beans addition, growth rate and feed conversion values were superior to the controls at high nutrient densities. The effect of trial was shown to be of more importance than dietary ingredients with reduced growth rate being noted in trial 1. This is shown by the difference in growth rate of control fed broilers because the control diets were manufactured from identical formulations in all three trials. Despite differences in growth rate among trials the influence of nutrient density remained similar.

Lowering nutrient density also reduced carcass grades for fleshing and fat. Grading was accomplished by using a subjective numerical grade ranging from 1 to 9 with the highest grade being 9. Despite a reduction in fat grades, virtually all birds still fell into the Agriculture Canada "A" grade (numerical grades 7, 8 and 9) and therefore is of minor importance. Reducing carcass fat may in fact be considered an advantage. The reduction in fleshing grade is more significant as a higher proportion of carcasses fall into the Agriculture Canada "B" and "C" grades. However this observation must be reexamined to determine if the influence of nutrient density is on fleshing grade alone or just on body weight. In the present studies broiler carcasses were graded at 7 weeks of age when differences in body weight due to treatments exist. In upcoming work broilers will be marketed at a specific weight rather than age which will remove the confounding influence of body weight differences.

The incidence of acute or sudden death syndrome was reduced in broilers fed low nutrient density diets. Previous studies have suggested that larger, rapidly growing birds are more susceptible to this syndrome and therefore the reduced incidence noted above may be a reflection of growth

rate. Leg problems were not influenced by nutrient density but indications of a higher incidence in Canola meal treatments was noted. In an attempt to show the economic importance of this research, the biological data from one trial and feed ingredient prices from 1975, 1979 and 1982 were combined to select the most economic feeding program. Using either 1975 or 1982 feed ingredient costs, differences in feed ingredient costs per 1.8 Kg broiler were small (4¢), suggesting minimal advantage to select a nutrient density other than those now commonly used. (Interestingly the lowest feed ingredient costs were for the treatment with a starter ME of 2935 Kcal/Kg). However using 1979 feed ingredient costs, there was almost a 20¢ per bird advantage in using the lowest nutrient density feeding program.

IMPACT

Additional information has been obtained on the effect of nutrient density and feed ingredient type in broiler productivity. This strengthens the designing of a model to select the optimum nutrient density for broiler rations.

Table 1: The effect of nutrient density and feed ingredients on the 7 week body weight of chicken broilers

Dietary ME, Kcal/Kg		Body weight (g)					
		Trial 1		Trial 2		Trial 3	
Starter	Finisher	Canola meal[1]	Control[2]	Faba beans[3]	Control[2]	Triticale[4]	Control[2]
3100	3180	1937	1970	2139	2081	2063	2068
3000	3078	1904	1940	2109	1972	2059	2070
2900	2975	1852	1921	2002	2034	2057	2067
2800	2872	1822	1738	2027	1971	2041	1998
2700	2770	1683	1698	1892	1899	1899	1926

[1]Diets contained 20% Canola meal.
[2]Control rations formulated with varying proportions of wheat, barley, soybean meal and tallow.
[3]Diets contained 20% raw faba beans.
[4]Triticale replaced all of wheat in control rations.

Table 2: The effect of nutrient density and feed ingredients on feed conversion of broilers from 0 to 7 weeks of age.

Dietary ME, Kcal/Kg		Feed conversion (Feed ÷ Body Weight)					
		Trial 1		Trial 2		Trial 3	
Starter	Finisher	Canola meal[1]	Control[2]	Faba beans[3]	Control[2]	Triticale[3]	Control[2]
3100	3180	2.001	2.002	1.934	2.015	2.033	1.978
3000	3078	2.003	2.058	1.989	2.032	2.056	2.020
2900	2975	2.037	2.125	2.034	2.123	2.070	2.082
2800	2872	2.110	2.110	2.134	2.174	2.146	2.090
2700	2770	2.116	2.170	2.206	2.218	2.192	2.253

[1]Diets contained 20% Canola meal.
[2]Control rations formulated with varying proportions of wheat, barley, soybean meal and tallow.
[3]Diets contained 20% raw faba beans.
[4]Triticale replaced all of wheat in control rations.

THE FEASIBILITY OF UTILIZING SASKATCHEWAN REARED HONEYBEE QUEENS IN COMMERCIAL HONEY PRODUCTION

T. Taylor and S. Clifford

ABSTRACT

Continuous overwintering of honeybee colonies in Northern climates is beset with two problems; 1. the loss of colonies through unsuccessful natural queen superceedures and overwintering hardships. 2. the need to maintain colony numbers as a direct result of these losses. This need is now serviced by importing package bees from the United States each spring. Two techniques of queen replacement were tested; 1. brood and queen transfers showed that from 45% to 66% of treated colonies accepted and maintained the newly introduced queens. 2. Cell technique; inclement weather in the fall prevented the final colony checks to determine the success level achieved. Spring 1983 inspections will reveal the required information.

Colony losses can reasonably be expected to be made up from within the bee operation itself. Full strength colonies were divided into a number of smaller colonies and queen cells were added. These colonies developed during the ensueing summer to nearly equal the populations of the

producing colonies by September. The current technique used would indicate that replacement colonies produced by this method would compete favorably on a cost basis with the alternative of buying package bees from the United States.

BACKGROUND AND OBJECTIVES

Over-wintering losses in Saskatchewan now approach 25% ($375,000). In most cases these losses can be traced back to a queen failure. Those losses which are not due directly to a queen failure may have come about as a result of the queens' non winter hardy genetic characteristics. In either event a young queen of desirable genetic background would likely have prevented the loss. Regular replacement of queens (improved queen management) would likely improve current honey production of over-wintered colonies by as much as 25% to 40% ($1.4 to 2.2 million). Colonies can be requeened easily if first the old queen is removed. However; the time involved in locating old queens in populous colonies is prohibitive in terms of labor costs and in terms of total time available in a given season to perform this task. Therefore a method of requeening without first dequeening the colony is highly desirable.

As a direct result of these losses beekeepers import 25% of their over-wintered colony numbers just to maintain their colony count. Any expansion is also achieved through bee imports from the United States. A reliable inhouse method of generating replacement colonies to maintian colony count is needed.

The inevitability of the Africanized bee reaching the queen and bee breeding areas of the United States makes it imperative that the techniques of being self sufficient be determined in advance. A reduction in the queen losses of over-wintered colonies together with a reliable method of replacing colony losses will make it more attractive for the remaining 45% of Saskatchewans' colonies to be over-wintered.

EXPERIMENTAL METHOD

Replacement colony production

Two groups of over-wintered colonies were divided to make five new colonies from each original colony. Each new colony or "nuc" was started with two frames of brood well covered with bees and a ripe (10 day old) queen cell. The first group being divided on June 14th and the second on June 26th.

Requeening via brood-queen transfers.

Two groups of colonies, one over-wintered the other current season packages, were requeened with Saskatchewan mated queens. These queens were produced as follows. Three frame nucs were started by removing a

frame of hatching brood and bees from the colony that was to be requeened. A queen cell was added at this time and the bees were confined inside the three frame nuc for 48 hrs before flight was allowed. At the time of the first honey removal, a space was made in the center of the second brood chamber to accomodate the three frames from the nuc. The new queen (marked) and her brood were transfered directly into the second brood chamber of the producing colony. The honey management and fall management of the requeened colonies was not altered in any way from normal production colonies in the apiary.

Requeening via "cell technique".

In May 100 over-wintered colonies were searched for queens and the queens then marked. Queen cells were prepared early in July and the 100 colonies were prepared to receive them. Ripe (10 day old) cells were placed between the top bars of the forth and fifth comb of the third hive body on July 12th and 13th. Honey managment and fall management of these colonies was not altered from normal colonies in the apiaries.

RESULTS AND DISCUSSION

Replacement colony production.

In the two groups of nuc hives set up the queen mating success rate was 80% for June 14th and 88% for June 26th. The effective number of successful divides per over-wintered colony was 4.16 and 4.4 respectively. The earlier group was able to achieve an average of 9 kg (20 lbs.) of surplus honey, within a range from 0 to 18 kg (0 to 40 lbs.). The later group (June 26) produced no surplus honey. Early September populations ranged from 12 to 18 frames of bees in the early group and from 9 to 16 frames in the later group. Both groups required approximately 11.4 kg of sugar (25 lbs.) in syrup from the supplement existing stores of winter feed. Total colony weights were brought up to 61 to 64 kg (135 to 140 lbs.).

It would appear that starting the nucs as early in June as weather will permit would be desirable as this will allow for some surplus honey production in the nucs, first year along with achieving larger populations. Larger populations are more successfully over-wintered. The revenue from the surplus honey production more than compensates for the cost of fall supplemental feeding.

Total costs as detailed in table 1 to have a replacement colony on line the following spring would be approximately $23.00 which compares favorably with the alternative, package bees. Two and three lb. packages delivered to Saskatchewan are approximately $26.00 and $35.00 respectively. Next years' honey production of these replacements in relation to package colonies will be the test of their true worth.

Requeening via a brood-queen transfers.

Late summer inspections of colonies that were given brood-queen transfers showed that 45% of over-wintered colonies and 66% of package colonies accepted and maintained the newly introduced queens. In all colonies except one, the unmarked queens (queens not replaced) appeared to be of a young age. This would indicate that the goal of having a young queen in each hive prior to winter was achieved. This test will have to be replicated several times under different summer conditions to determine its real effectiveness.

Requeening via "cell technique".

Inclement weather in the fall prevented the completion of the final inspections of the "celled" colonies to determine the effectiveness of the technique. All of these colonies have been put into winter and it will be possible to complete the queen checks in the spring. Where a marked queen is found it wil show that the new queen was not accepted. However; where an unmarked queen is found we must assume that the queen from the cell or a queen from a natural superceedure is now heading up the colony. In either event the end result would be a new queen in the colony. If this technique would consistantly yield success rate of 50% or more it would be a very economical method of introducing queens.

Table 1.
Costs to produce replacement colonies:

Cost of colonies to be divided;		
fall feed (45 lbs. 40 cents/lb.)	18.00	
insulation, labor and transporation	2.00	
	20.00	20.00
Assume 15% winter loss		3.50
Inputs until time of division		
labor	3.00	
sugar	7.00	
transportation	2.00	
	12.00	12.00
Cost per colony to be divided		35.50
Cost per replacement colony;		
bees and brood ($35.50/4)	8.90	
queen cell	2.50	
opportunity costs of equipment	6.40	
honey production less sugar fed	0.00	
insulation, labor and transporation	2.00	
	19.80	19.80
Assume 15% winter loss		3.50
Cost per replacement colony on line the following season		23.30

TRACTION OF SOWS WHILE HAULING A LOAD ON DIFFERENT FLOOR TYPES

G.I. Christison

ABSTRACT

The foothold of sows while in farrowing crates has an important influence on the number of newborn pigs which are crushed by the sow. One potential method of evaluating a sow's foothold was to determine her ability to haul a load while walking on floors of different types. When trained sows were used, however, the floor-to-floor differences were too small to provide a useful method of distinguishing among floor types.

BACKGROUND AND OJBECTIVES

Approximately one-half of the newborn pigs which die before weaning are killed by overlaying of the sow. Many of these are weak pigs which would die of other causes, but the nimbleness of the dam and sureness of her footing are key factors influencing crushing losses of healthy piglets. There is no good information available concerning the goodness of traction on various farrowing crate floors, nor is it known how best to measure that traction.

As part of an ongoing project, a variety of approaches are being used to evaluate traction of sows on different floors. The first technique examined was to measure the ability of sows to haul a load while walking on different floor types. Earlier work of ours had shown this procedure to be an effective method of evaluation with young pigs.

EXPERIMENTAL METHOD

The pulling force of eight dry sows while on seven different floor types was recorded by having the sows wear a harness attached via a strong spring to a load cell. On trial days, each sow was moved from her pen to an experimental stall where the floor was changed daily. She was harnessed to the load cell and urged to haul against the spring three times before returning to her pen. With the exception of concrete and the metal floor with round holes, each floor was tested both along and across the direction of the perforations. The same eight sows were used for all experiments. Each floor-direction combination was evaluated by all sows on two occasions.

RESULTS AND DISCUSSION

There was no difference between the first and second runs of the experiment. Two of the sows consistently pulled significantly harder than the other six (Table 1). Although there are apparent differences in the ability of sows to pull along or across the direction of the

perforations on some floors, none of these differences are significant ($P < 0.05$) for any one floor type (Table 2). When the average pulling force on each floor was considered, there were differences ($P < 0.05$) among floors (Table 2) but these differences were inconsistent with subjective evaluations of the traction on the various floor types.

It was concluded that the technique of measuring the load-hauling ability of sows on different floor types was not a useful technique for distinguishing among floors. The probable reason for the lack of success with sows, as distinct from the effectiveness of the procedure with young pigs, is that the sows were used repeatedly. The sows went through a training phase and were then each exposed to the test situation on a total of twenty-four occasions. Thirty young pigs were used for each floor type, but they were untrained and were each used on a single occasion. All of the sows, except number 6 (Table 1), quickly learned that gentle pulls were adequate to complete each trial. Thus, the security of the sow's foothold was not an important factor affecting the pulling force.

IMPACT

The ability of trained sows to haul a load while on different floor types is not an effective technique for the evaluation of the traction of the sows on these floors.

Table 1. Mean pulling force (kg/kg body weight) of individual sows*.

	Sow number							
	1	2	3	4	5	6	7	8
Force	0.21	0.20	0.18	0.24	0.27	1.50	0.29	0.46

* Means which differ by more than 0.14 are significantly different ($P < 0.05$)

Table 2. Pulling force (kg/kg body weight) of sows on various floors*

	Direction +		
Floor	Along	Across	Average
Plastic-coated expanded metal	0.41	0.34	0.38
Molded plastic	0.36	0.52	0.46
Perforated metal slats	0.38	0.33	0.35
Fiberglass slats	0.36	0.50	0.43
Woven Wire	0.33	0.47	0.40
Perforated metal with round holes	0.51		0.51
Concrete	0.53		0.53

* Means in the direction columns which differ by more than 0.16, or in the average column which differ by more than 0.12, are significantly different ($P < 0.05$).

+ Relative to the direction of the perforations.

THE ECOLOGY OF THAMNOPHIS RADIX IN SOUTHEASTERN SASKATCHEWAN

D.M. Secoy and M. Selinger-Dukart

ABSTRACT

A population of the plains garter snake, the most abundant reptile in the province of Saskatchewan, was studied near Kronau. The study site was a portion of the Manybone Creek valley with grassland interrupted by patches of shrubs and herbaceous species along the creek.

Over the two field seasons 241 individuals were marked, and recaptured 755 times. The population in 1982 was 50.5% adult (27.3% male, 23.2% female) and 49.5% juvenile or young-of-the-year. In that year 30.4% of the females were gravid, indicating variation from an annual breeding cycle. Growth was variable.

The population did not migrate from the creek area. The average home range of the adults was 1.6 hectares with no defense of home range and considerable overlap. The population dens in rodent burrows and the root systems of various plants. Food found in the snakes were from the creek, being comprised mainly of leeches and small fish, with tadpoles and aquatic insect larvae.

BACKGROUND AND OBJECTIVES

Thamnophis radix, the plain's garter snake, is the most abundant snake in the province of Saskatchewan. This species has caused considerable concern among rural and urban residents of southern Saskatchewan due to its useage of man-made structures as hibernacula. This species, therefore, is considered to be a pest by a segment of the population, although it is not a dangerous animal.

Within the scope of this stdy, population structure, den site location, movements and food habits of a population of plain's garter snakes were considered through the active seasons of 1981 and 1982.

EXPERIMENTAL METHOD

Study Area

The study site is a 250 hectare area encompassing a portion of Manybone Creek east of the town of Kronau in southeastern Saskatchewan.

The immediate habitat is predominately wheat grass (Agropyron sp.) and blue grass (Poa sp.) distributed fairly uniformly throughout the area. Rose (Rosa sp.) and snowberry (Symphoricarpus sp.) are found clumped

extensively along the creek itself. Disturbance of the habitat has been largely due to grazing by domestic cattle. Although grazed heavily during the 1981 season, some recovery was noted during the 1982 season. The creek is gently meandering and attains a maximum depth of two meters. To the south of the study area the creek has been dammed and a recreational area is located. The area directly adjacent to the study site was and remains under cultivation.

Methods

This study was conducted over the active periods of 1981 and 1982. Trips to the area were made on a daily basis throughout the seasons. Individuals were captured by hand, marked using a ventral scale clipping technique (Brown and Parker 1976), sexed (Finch 1960), the snout-vent lengths recorded, and then released. All recaptures were ntoed each day.

Each snake had its own map drawn to scale so that movements and directional aspects of such movements could be determined. Road kill counts and shedding records were kept in order to supplement movement data. Home ranges were calculated for all individuals which had been captured at least three times by the convex polygon method. To eliminate sample size bias of the polygon technique, adjustments were made as suggested by Jennrich and Turner (1969). This adjustment has been questioned (Rose 1982) but is considered valid by many researchers.

Stomach contents were collected using an enteric lavage method (Legler 1977) and subsequently analyzed. This technique allowed a frequency of occurrence type of food analysis.

Gravid females were collected and maintained at the Unviersity of Regina until partuition. Date of partuition, number of progeny and the progeny's snout-vent lengths were recorded.

RESULTS AND DISCUSSION

In total, 241 individuals were marked and released into the population (175 in 1981 and 66 in 1982). Over the active periods of 1981-1982, these 241 individuals were recaptured 755 times (411 in 1981 and 344 in 1982). In the context of this study juveniles were defined as those individuals which could not be definitely sexed. In 1982, 27.3%of the population were male; 23.2% were female; 18.7% were juvenile and 30.8% were young of the year (Table 1). The largest individual captured was a female measuring 783 mm. Only 30.4% of the females found in 1982 were gravid. This would suggest that reproduction in this population is not annual.

In 1982, three gravid females were collected in mid August and maintained at the University of Regina until partuition. The average brood size was

19.3 young with an overall average snout-vent length of 172.33 mm. The largest litter contained 28 individuals (Table 2).

Since snout-vent lengths were noted upon each recapture, the growth rate could be calculated (Table 3). The growing season in this case is synonymous with the active season; that is, the period of April to October inclusive. Data include juveniles with 3 or more days between captures and adults with 30 or more days between captures. The percentage increase of snout-vent length per growing month was obtained by dividing the increase between captures by the length of the snake at the beginning of the period and then dividing by the number of elapsed growing months. Growth rates in garter snakes are highly variable. Rates are influenced by factors including availability of food, weather, date of birth (i.e. time for growth before hibernation), size at birth and genetic constitution (Stewart 1968). Variation in the rate of growth of T. radix is obvious from the data, although a consistently higher growth rate among juveniles is apparent. Fitch (1949) reported an average growth rate of 11.5 mm/week in first year individuals. Such results are closely approximated by the findings of this study.

Den sites were found to be scattered throughout the study area. In this population of plain's garter snakes, abandoned ground squirrel burrows and the root systems of various trees were utilized as den sites. T. radix brumates in small numbers, mating soon after emergence. Size of the snake and availability of large hibernacula account for a small observed denning population (Gregory 1977).

The term home range as used in the context of this paper refers to the area in which the animal normally lives, exclusive of migrations, emigrations or unusual or erratic wanderings (Brown and Parker 1976). Home ranges were calculated for all individuals which were captured at least three times during the field season (Table 4). Generally males appear to have a larger home range than females. Average adult home range was found to be larger than that of juveniles. The overall average home range among snakes during the 1982 season was found to be 1.57 hectares.

This population did not appear to migrate outide of the study area. These findings contrast those of Gregory and Stewart (1975) who found that Thamnophis sirtalis of the Interlake region of Manitoba migrated up to 18 km. from the hibernacula to the summer feeding area. The stationary nature of the population under study may partially by explained by a readily available food supply in the study area.

Therefore a migration, such as that observed in Manitoba, in order to find a marshlike habitat and food items would not be expected. Similar findings have been reported in Montana (Anderson 1977).

A stomach contents analysis was undertaken over the two year period (Table 5). The percentage of snake stomachs containing food over the

active season ranged from a high of 57.2% in May to 0% in late September. Empty stomachs comprised 72.6% of those stomachs sampled in 1982. Such a high percentage of empty stomachs is not uncommon among snakes (Kephart and Arnold 1982). The literature mentions earthworms, amphibians (Pseudacris triseriata and Rana sylvatica), leeches, tadpoles and fish as typical items in the diet of T. radix (Jordan 1967, Gregory 1977). Mammals represent only an occasional food item in the diet (Gregory, Macartnay and Rivard 1970), which is sub-stantiated by this study. The data presented here depend upon availability of food in the study area and therefore may reflect a "local specialization" of this population of T. radix. The leech (Helobdella sp.) and minnow (Notropis sp.) were common in the stream throughout the summer.

It is of interst that more than one type of food item was found in a number of cases. In 1982 30% of those individuals which contained food contained more than one type of food item. Additonally, in 17 of the instances where food was found over the 1981-1982 active seasons more than one individual of a particular type was found. In 1982, for example, there are a number of cases where more than one leech was found in a snake stomach-ranging from 2 to 12 individuals. Similarly the number of minnows found at one time in a given stomach ranged from 2 to 4 individuals.

IMPACT

Thamnophis radix, the plain's garter snake, brumates in small numbers utilizing abandoned rodent burrows and the root systems of various trees as hibernacula. The population studied did not migrate over long distances but was relatively stationary. Generally males had a larger home range than females. Adults generally had a larger home range as compared to juveniles. In 1982, the population was roughly composed of 27.3% males; 23.2% females; 18.7% juveniles and 30.8% young of the year. Average brood size was 19.3 young with a snout-vent lenth of 172.33 mm. Overall it would appear that plain's garter snakes are aquatic feeders utilizing leeches and minnows primarily as food items.

Table 1. Composition of a population of Thamnophis radix in southern Saskatchewan, summer 1982.

Snout-vent Length (mm)	Males (n=54)	Females (n=46)	Juveniles (n=37)	Young of the year (n=61)
151-200				61
201-250				
251-300			3	
301-350			12	
351-400			7	
401-450		2	9	
451-500	7	2	6	
501-550	24	9		
551-600	20	9		
601-650	3	12		
651-700		9		
701-750				
751-800		3		

Table 2. Summary of information on litter size in Thamnophis radix as compared to maternal snout-vent length as determined through normal partuition in 1982. All measurements were taken on live specimens and recorded to the nearest millimeter.

Snout-vent Length of Female	Days Held Prior to Partuition	Average Snout-vent Length of Young	Range of Snout-vent Lengths of Young	Actual Litter Size	Number of dead Embryos
588	18	154	141-161	16	5
658	2	188	181-196	14	0
668	11	178	170-186	28	0

Table 3. Growth rate of T. radix over the active periods of 1982 and 1983.

Initial Snout-vent Length (mm)	Males Increase mm/month			Females Increase mm/month			Juveniles Increase mm/month		
	N	$\bar{X}$	Range	N	$\bar{X}$	Range	N	$\bar{X}$	Range
200-250	1	67.30					1	31.07	
251-300							4	37.86	37.05- 64.29
301-350	2	61.49	31.02-91.97	1	21.43		8	35.25	1.17- 86.40
351-400	3	15.42	5.14-25.70	1	4.41		3	51.47	38.40- 75.71
401-450	12	19.29	5.14-90.88	2	17.09	11.89-22.30	4	36.68	9.55-100.00
451-500	16	11.21	3.47-30.87	2	10.97	7.20-14.74	1	5.33	
501-550	22	11.94	1.61-52.5	15	12.26	2.18-34.8			
551-600	4	7.31	4.40-12.90	11	11.24	4.63-22.38			
601-650				8	6.25	.70-11.11			
651-700				1	3.21				

Table 4. Comparison of home range size (hectares) in Thamnophis radix as a function of method.

		Number Of Sightings		Convex Polygon	Jennrich and Turner Treatment
1982	N	$\bar{X} \pm SE$	Range	$\bar{X} \pm SE$	$\bar{X} \pm SE$
Males	23	5.61 ± 3.22	3-15	2.29 ± 0.68	16.12 ± 3.88
Females	16	4.69 ± 1.24	3-7	1.76 ± 0.69	16.36 ± 6.80
Juveniles	5	6.00 ± 3.67	3-12	.65 ± 0.53	3.14 ± 1.56

Table 5. Results of stomach analysis of Thamnophis radix for the active period of 1982.

Food Type	1982 (n=146)	Frequency of occurrence % of stomachs containing item (n=40)	% of total items (n=54)
No contents	106		
Contents	40		
Helobdella sp.	25	62.50	46.30
Notropis sp.	10	25.00	18.52
Rana pipiens	1	2.50	1.85
Ambystoma tigrinum	2	5.00	3.70
Dragon fly larva	1	2.50	1.85
Snail egg mass	2	5.00	3.70
Vertebrate remains	5	12.50	9.26
Invertebrate remains	5	12.50	9.26
Unidentified remains	3	7.50	5.56

THE IMPLEMENTATION AND DEMONSTRATION OF AN IMPROVED POST-WEANING ENVIRONMENT FOR PIGS AND THE RESULTANT INFLUENCE ON PRODUCTIVITY IN RESPIRATORY DISEASE PATHOLOGY

H. Fast, S.D. Acres, and P. Willson

ABSTRACT

The impact of different nursery systems on the level of respiratory diseases in, and the production performance of pigs was evaluated. A room nursery, for use in herds having more than 100 sows, was designed and constructed and the performance of pigs weaned into the all-in-all-out nursery rooms was compared to that of pigs weaned onto traditional raised flat decks occupied on a continual basis. There was a significant improvement in the average daily gain and a significant reduction in the mortality rate of pigs weaned into the all-in-all-out nursery rooms as compared to the flat deck system. When the nursery rooms were fitted with an electrostatic air filter there was a further improvement in average daily gain and a decrease in the amount of pneumonia seen at slaughter. However, commercially available electrostatic air filters did not have the capacity necessary to adequately service nursery rooms and they cannot be recommended for use in commercial herds. Inexpensive, plywood box nurseries for use in herds having fewer than 70 sows were also constructed and used in two commercial herds. The pigs weaned into the box nurseries did not show any significant improvement in production performance or health status. Hence, they appear to be of little use during the post-weaning period.

BACKGROUND AND OBJECTIVES

Swine respiratory diseases which affect the upper (atrophic rhinitis) and lower respiratory systems (chronic pneumonia) have a common and worldwide occurence. The economic losses associated with these diseases are variable, but are generally conceded to be high and they are recognized as one of the most costly diseases for swine producers. While a number of identified infectious agents play a significant role in causing these diseases, the specific mechanisms by which they impair productivity have not been clearly defined. Furthermore, in a hog unit the role of these infectious pathogens is generally complicated by their multiplicity, and interaction with the host and the environment. Several approaches have been used to try and prevent and control these diseases. The use of antibiotics has had little impact on reducing the production losses caused by atrohpic rhinitis or chronic pneumonia. Vaccines are also available for atrophic rhinitis; however, their efficacy has not been clearly demonstrated under natural conditions. Finally, various attempts have been made to improve the environment as a means of decreasing the exposure of pigs to infectious agents and thereby reduce disease losses.

The objective of this study was to design, construct and test the effect of using two different types of nursery systems during the immediate post-weaning period on reducing production losses caused by atrophic rhinitis and pneumonia.

EXPERIMENTAL METHOD

Two types of nursery systems were designed and constructed. Room nursery - With the aid of the VIDO Swine Technical Group a room nursery for use in herds having 100 or more sows was designed and built. The detailed design and construction plans for the nursery are outlined in the bulletin entitled "Swine Nursery Design". The nursery was built into an existing swine barn and consisted of three rooms, each with a total capacity of 40 to 50 pigs. Each room was divided into 6 separate pens, each of which housed 7 to 8 pigs. Pigs were weaned directly into the nursery where they were raised for 6 weeks, prior to being moved into the feeder barn. Between each cycle, the nursery rooms were cleaned and disinfected using a high pressure sprayer. For comparison, the performance of pigs weaned into the nursery rooms was compared to those weaned into one large traditional post-weaning room equipped with raised flat decks and managed on a continuous occupancy basis.

The performance of pigs weaned into the room nursery was monitored over a 15 month period. During the first half of this interval all three nursery rooms were managed similarly and the performance of pigs in the room nurseries was compared to those in the traditional raised flat deck system. During the second half of this interval approximately 1/3 of the pigs entering the room nurseries were vaccinated with the commercial vaccine for atrophic rhinitis (Atrogen-P, Connaught Laboratories Limited, Toronto, Ontario. This vaccine contains Bordetella bronchiseptica and Pasteurella multocida). In addition, approximately 15% of the pigs were weaned into a room nursery equipped with an electrostatic air cleaner (Electrohome Model EF, 120 Volt, 6 Amp) in an attempt to reduce the level of airborne microorganisms found in the room.

Box Nurseries - These were of simple design and construction and were an attempt to provide an inexpensive alternative to room nurseries for use in smaller herds (ie. fewer than 100 sows). The boxes were approximately 1.05 m wide by 1.58 m long by 0.53m deep and were constructed of 11 mm plywood. Lumber, 33 mm x 77 mm, was used as framing support. There was a hinged lid covering the top of the unit. The front was made of two sliding panels which could be removed for cleaning. Each box held approximately 12 pigs. The front 2/3 of the floor was of solid plywood construction and the back 1/3 was a dunging area consisting of fibreglass T-bar slats extending across the width of the box. Fresh air intake into the box was from 18.8 cm PVC pipe. There were two 8.8 cm PVC ducts in the lid of the box above the slatted area to improve ventilation. The air to the box was piped from an area of the barn in which pigs were not raised. Weather stripping was placed around the edges of the lid to help room air from entering the box. Water was available continuously from

two lixit nipples positioned on the sides of the box over the rear slatted area. Feed was available adlibidum from a self-feeder at the front of the box. The labor and material costs for each box was $428.00.

It was hoped that if the plywood boxes provided an isolated microenvironment that an improvement in growth performance and reduction in respiratory pathology would be seen. The box nurseries were used in two herds.

Herd 1. At weaning, pigs were randomly placed into box nurseries, a commercial flat deck system, or on the floor. After 3 weeks, the pigs in the box nurseries were removed and placed on the floor where they remained until being sold when they reached a body weight of approximately 15 kg.

Herd 2. Pigs were weaned every four to five weeks and placed into either a box nursery or onto flat decks. After two weeks, pigs weaned into boxes were moved onto the flat decks where they were reared until sale at approximately 18 kg.

In both nursery systems, records were kept of feed consumption, weight of pigs when entering and leaving the nursery system and mortality during the weaning period. Pigs in the room nursery trial were followed to slaughter and the degree of pathology in the respiratory tract was determined and quantitated using methods previously published in the literature. The degree of atrophic rhinitis was scored from 0 (normal) to 5 (very severe atrophic rhinitis). The amount of pneumonia in various lobes of the lung was also quantitated and scored and the occurrence of pleuritis was also noted.

RESULTS AND DISCUSSION

Room Nurseries

During the first year of the trial, the average daily gain of pigs during the weaning period was significantly higher for pigs weaned into the room nurseries as compared to the continuous flat deck system (Table 1). In addition, the mortality rate was significantly reduced in pigs raised in the room nurseries. The improvement in average daily gain seen in pigs weaned into the room nurseries was not continued during the feeding period (Table 2). However, there was a significant decrease in the amount of pneumonia seen at slaughter in pigs raised in the room nurseries as compared to those raised in the continuous flat deck system (Table 2).

During the second year of the trial, there was a significant improvement in the lung score and average daily gain of pigs raised in nursery rooms equipped with an electrostatic air filtration device (Table 3); however, the nose scores were increased. It should be pointed out that the electrostatic air filter used did not have the capacity to adequately

service the room nursery. The machines had to be cleaned regularly and data on some rooms of pigs was lost because the equipment failed during the 6-week interval for which pigs were housed in the room. In fact, to adequately conduct the experiment, two machines were purchased and alternated weekly within the treatment room. Therefore, while electrostatic air filtration reduced the amount of lung pathology and increased average daily gain, the equipment which is currently available to producers cannot be recommended for this purpose. It appears that heavy duty industrial-type electrostatic air filters may be required to adequately handle the dust load found in most pig barns. There was no significant improvement in performance parameters of pigs vaccinated with the atrophic rhinitis vaccine (not shown).

Box Nurseries

Herd 1. During the 3-week period immediately after weaning, average daily gain was greatest in pigs in the raised decks (Table 4). However, this advantage was not maintained during the follow-up nursery period. The amount of feed required to produce a kilogram of body weight gain was also lowest in pigs in the raised decks. This difference appeared to be due to considerable wastage of feed by the pigs in the other two systems. The high mortality rate seen in pigs in all three groups was attributed to post-weaning diarrhea caused by K88+ Escherichia coli.

Herd 2. Average daily gain in pigs weaned into the boxes was 30 grams lower than those reared on decks (Table 5). Feed used per kilogram of gain also favored pigs raised on the decks. However, the amount of feed used from weaning to a body weight of 18 kg was not different between the two groups.

It has been demonstrated that rearing pigs in a way that allows all-in-all-out production reduces losses due to respiratory disease. It has been suggested that the use of inexpensive plywood boxes is a suitable alternative for achieving this purpose in herds with fewer than 100 sows. The herds which cooperated in this trial were of a typical size, management, and health status which would find plywood boxes an inexpensive alternative to constructing room nurseries necessary for larger herds. However, the results of this experiment did not show a positve response in average daily gain, feed conversion, or mortality, when pigs were weaned into plywood boxes and raised for either a two or three-week period. Several problems were encountered with the use of the boxes during the period of the trial. Firstly, as was pointed out above, there was considerable feed wastage. Secondly, during the winter months when the air entering the boxes was cool, the inside of the boxes remained dry and clean. However, during the summer when the incoming air was warm, the pigs would loaf on the slatted area under the air intake in an attempt to remain cool. Consequently, they manured on the solid portion of the floor near the self-feeders. An attempt was made to rectify this by constructing the front of the box from translucent plexiglass on the theory that the pigs would move off the slats towards the lighted area; however, this was unsuccessful. Hence the results

indicate that the use of plywood boxes described here was of no benefit and cannot be recommended at the present time.

IMPACT

In this study two nursery systems were designed, constructed, and used in commercial herds to determine their impact on reducing the level of atrophic rhinitis and pneumonia. The performance of pigs weaned into an all-in-all-out room nursery, designed for herds having $\geq$ 100 sows, was compared to pigs weaned onto traditional flat decks occupied continuously. During the post-weaning period, the average daily gain was significantly higher and the mortality rate significantly lower in pigs weaned into the nursery rooms. During the feeding period, there was no difference in the average daily gain between pigs raised in the two systems; however, the amount of pneumonia found at slaughter was significantly lower in pigs weaned into the nursery system. When nursery rooms were fitted with an electrostatic air filter there was a further improvement in lung score and average daily gain. The use of the vaccine for atrophic rhinitis has no effect on the performance of pigs. Hence, the use of room nurseries equipped with an electrostatic air filter provided greatest increase in performance. However, the air filters which are currently available on the market do not have the capacity to service rooms of the size used in this study and cannot be recommended to swine producers. However, additional studies on the benefits of electrostatic air filters should be done if machinery of sufficient design and capacity can be found. Box nurseries, while an inexpensive alternative to room nurseries, were of no benefit and can not be recommended to swine producers.

Table 1: Performance during the weaning period of pigs weaned into room nurseries and traditional nurseries. Year 1.

	Postweaning Housing	
Performance Parameter	All-In-All-Out Room Nurseries	Continuous Occupancy Raised Flat Deck System
Age at weaning (days)	28.70± 3.10	27.80± 3.0
Weight in (kg)	6.71± 0.94	7.10± 0.71
Average daily gain (g)	390±51[a]	321±50
Mortality rate (%)	1.35±1.87[a]	3.65±2.33
Number of pigs	815	411

[a] Significantly improved ($p<0.05$) from the control group.

Table 2. Performance at slaughter of pigs weaned into room nurseries and traditional nurseries. Year 1.

	Postweaning Housing	
Performance Parameter	All-In-All-Out Room Nurseries	Continuous Occupancy Raised Flat Deck System
Dressed slaughter wt (kg)	74.0	72.9
Nose score	1.84	2.05
Lung score	2.9 ±0.2[a]	4.6 ±0.4
Pleuritis	0.139	0.174
Average daily gain (g)	381±3	375±4
Number of pigs	315	148

[a] Significantly improved ($p<0.05$) from the control group.

Table 3: Performance at slaughter of pigs weaned into room nurseries with or without air filtration. Year 2.

Performance Parameter	Air Filter	No Air Filter	Performance Parameter	Air Filter	No Air Filter
Dressed market weight (kg)	76.2±1.0	74.5±1.5	Nose score	2.15±0.21[a]	1.72±0.36
Market age (days)	187.6±7.6	198.0±7.6	Lung score	2.19±0.28[a]	3.04±0.89
Pleuritis	0.063±0.050	0.151±0.090	Average daily gain (g)	4.15±15[b]	378±20

[a] Significantly different ($p<0.05$) from control group
[b] Significantly different ($p<0.02$) from control group

Table 4: Performance of pigs weaned into plywood box nurseries as compared to two toher systems. Herd 1.

	3 Week Post Weaning					Follow Up Nursery				
	No.	Weaning Age Days	Weaning Wt. Kg.	ADG* (gms)	Kg Feed Used/Kg Gain	Mortality %	ADG (gms)	Feed Conver. Ratio	Mortality %	Standardized 56 Day Wt. Kg
Boxes Nurseries	120	30.6	6.2	260	2.73	5	444	2.65	6.7	14.8
Concrete Floors	115	35.6	7.2	20	2.72	2.6	460	2.98	3.5	14.2
Raised Decks	67	29.8	5.6	310	1.83	7.5	410	2.62	9	14.0

Table 5: Performance of pigs weaned into plywood boxes as compared to raised decks. Herd 2.

	2 Weeks Post Weaning					Follow Up Nursery				
	No.	Weaning Age (days)	Weaning Wt. (Kg)	ADG* (gms)	Kg Feed Used / Kg Gain	Mortality %	ADG (gms)	Kg Feed Used / Kg Gain	No. Removed to Sick Pen(%)	Standardized 56 Day Wt. Kg
Plywood Boxes	343	29.9	7.4	80	2.50	.9	260	2.11	8(2.3)	13.9
Raised Decks	444	28.7	7.6	110	2.28	.2	270	2.23	12(2.7)	14.8

* ADG - Average Daily Gain

THE ECONOMICS OF WHEAT AND GRAIN/PROTEIN RATIOS IN GROWING/FINISHING HOG RATIONS

R. Blair, K.A. Rosassen, V.J. Racz and B. Rakshit

ABSTRACT

A total of 240 swine (168 castrates and 72 gilts) were employed in 4 blocks, over the weight range 20 to 100 kg. They were grouped 6 or 12 to a pen on a sex-separated basis and fed one of 4 grower diets (Diets EW 1 to 4) up to 50 kg, followed by one of 4 finisher diets (Diets EW 5 to 8) from 50 to 100 kg liveweight. All diets were fed ad libitum and were based on corn, wheat/barley, or barley. Those based on corn (EW 1/EW 5) and wheat/barley (EW 2/EW 6) were formulated to meet the NRC standards for energy and protein. One barley diet (EW 3/EW 7) supplied the NRC level of protein but with a reduced energy level similar to that found in Western Canadian diets. The other barley diet (EW 4/EW 8) contained the same reduced energy level, but with the same energy/protein ratio as in the corn and wheat-based diets.

Digestibility of dry matter and protein were higher in the corn and wheat-based diets than in the barly-based diets. The corn-based diet resulted in the fastest and most efficient growth in young growing swine and the wheat-based diet resulted in a slower growth that was comparable with that obtained with the barley diet containing the same protein level. The preliminary results from one block suggested that protein level rather than energy level has a critical effect on the growth of young growing swine. They also suggested that there may be little or no benefit from the inclusion of wheat in grower diets for swine.

BACKGROUND AND OBJECTIVES

Rations for growing swine in Western Canada are predominantly barley-based whereas rations fed in the east are usually corn-based. The barley-based rations with added soybean meal generally meet the protein and lysine levels recommended by the U.S. National Research Council-National Academy of Science (NRC) however these rations are usually lower in digestible energy (DE) than is recommended. Addition of wheat to grower and finisher diets for western pigs has been used extensively in an attempt to increase the energy content of the ration.

Wheat fed to pigs contains approximately 120 to 310 kcal/kg more DE than does barley (Wiseman 1979; Wiseman and Cole 1979). Wheat also contains more crude protein (CP) and has a higher % CP digestibility than barley, thus inclusion of wheat in the ration can substitute partially for protein supplement (Kromann et al. 1976).

One of the major problems facing swine producers in Western Canada is whether raising DE levels in feed to meet NRC recommendations is more economical than feeding lower energy barley-based diets.

It has been consistently shown that increasing daily energy intake results in faster weight gain (Barber et al. 1972; Wood et al. 1979; Podletskaya and Morgunova 1980). DeGoey and Ewan (1975) found a high correlation between energy gain and metabolizable energy (ME) intake. High energy intake can also result in more fat being deposited (Barber et al. 1972; Wood et al. 1979; Giles et al. 1981) which may reduce the value of the carcass. Wood et al. (1979) found weanling pigs fed 33% more energy per day than a control group deposited fat 55% faster than the controls. Both groups deposited lean in the ham at the same rate. Godfrey and Dunkin (1980) concluded that the most profitable feeding regime depended on method of selling, grading schedule and the value of growth rate. A low daily energy intake produced a leaner carcass but increased the days to market, whereas a higher daily energy intake produced a fatter carcass in a shorter time.

The effect of rate of energy intake on feed conversion ratio (FCR) has not been well established. Godfrey and Dunkin (1980) reported no significant effect on FCR when DE intake was reduced by 10%. This supports previous work by Barber et al. (1972) in which six groups of pigs fed daily intakes ranging from 1.99 to 2.50 kg/day of the same diet (3,000 kcal DE/kg) showed small and non-significant differences in FCR. The literature supporting an effect of energy intake on FCR is inconclusive and contradicory. Several experiments show that higher energy intake reduces efficiency of gain. In one trial (Podletskaya and Morgunova 1980), eight-week-old pigs raised on 15-20% higher energy intake than a control group had a 10.3 to 17.5% higher feed intake/unit gain ratio. This effect was also reported by Woods et al. (1979) and Gamko (1980). Gamko found that up to 50 kg liveweight, 1,500 kcal more energy was required per kg gain when pigs were fed 120% versus 80% recommended energy. From 50 kg to 80 kg liveweight the pigs fed above or below 100% recommended energy levels were both more efficient than those fed 100%. Giles et al. (1981) found a significant improvement in FCR ($P<0.01$) when energy intake was reduced by 25% from ad libitum.

Significant evidence, however, for an increase in feed efficiency with a rise in energy intake also exists. Coffey et al. (1982) compared pigs fed equal daily amounts of diets containing 3,140, 3,340 and 3,540 kcal DE/kg. He found pigs were more efficient ($P<0.05$) in converting feed to weight gain with each higher increment of energy. In another experiment (DeGoey and Ewan 1975), feed/gain ratios, although not significantly different, consistently decreased as energy consumption increased.

O'Grady (1978) found a higher energy density diet (3,489 versus 3,250 kcal DE/kg) resulted in improved feed efficiency. Because the feed intake of pigs fed 3,489 kcal DE/kg (HE) was lower than those fed 3,250

kcal DE/kg (DE) the average daily DE intake was only 47.9 kcal/day higher in the DE pigs. It is impossible to say whether the increased feed efficiency was due to higher DE density or to slightly higher daily DE intake. Increasing the energy density did not affect growth rate, probably because the daily energy intake was not markedly increased. The energy was used more efficiently by the LE pigs ($P<0.001$) where 2 g more gain was recorded per 239 kcal DE consumed. This conflicts with results of a recent trial by Coffey et al. (1982) who found that energy efficiency increased with an increase in dietary energy density. However, this increase was not statistically significant and was only seen in the warm months. During the cool season they found that energy efficiency remained the same or decreased slightly with an increase in dietary energy density.

Thus it has been shown that energy density of the diet (O'Grady 1978; Coffey et al. 1982) and daily energy intake (Barber et al. 1972; Gamko 1980; Godfrey and Dunkin 1980; Podletskaya and Morgunova 1980; Calabotta et al. 1982) influence the performance of growing pigs. Due to the discrepancy seen in the effects of these factors on feed and energy efficiency, further study in this area is required before the most economical feeding schedule can be determined accurately.

The objectives of this investigation were to:

1) Determine the optimal grain/protein ratios in Western hog rations.
2) Devise an economic model for the inclusion of wheat in hog grower rations.
   a) as an energy source
   b) as a protein source
3) Provide data on energy/protein responses for use in extension programs for swine producers in Western Canada.

EXPERIMENTAL METHOD

A total of 240 animals (168 castrates and 72 gilts) were employed, over the weight range 20 to 100 kg. They were grouped 6 or 12 to a pen on a sex-separated basis and fed one of 4 grower diets (Diets 1 to 4: Table 1) up to 50 kg followed by one of 4 finisher diets (Diets EW 5 to 8: Table 1) from 50 to 100 kg liveweight. All diets were fed ad libitum. Individual liveweights and feed intakes per pen were recorded weekly. On reaching the appropriate liveweight each animal was sent for slaughter and graded according to the ROP Carcass Appraisal Scheme which gives detailed information on carcass quality.

Digestibility of dietary dry matter and crude protein were also determined in one block of animals, together with digestible energy.

Diets and data were analyzed according to established techniques.

RESULTS AND DISCUSSION

The experiment is almost complete, with 48 remaining animals due for slaughter by the planned completion date of May 31, 1983.

To date the results from one group (48) of animals over the first 4 weeks of test have been analyzed (Table 2). These data show that a corn-based diet formulated to NRC specifications gave the best and most efficient gain in young growing pigs. A wheat-based diet formulated to the same specifications gave slower and less efficient growth. A barley-based diet containing no wheat and with an energy (DE) level lower than that specified by the NRC gave as good growth as that obtained with the wheat-based diet, and gain/feed ratio was higher with the barley-based diet. A diet based on barley and with a DE/CP ratio similar to that used in the corn and wheat-based diets gave poorer performance, suggesting that protein rather than energy has a critical effect on growth performance.

Digestibility of dry matter and protein were significantly higher in the corn and wheat-based diets than in the other diets.

These results suggest that there may be little or no benefit in including wheat in grower diets for swine. However, they will have to be verified, and a more complete analysis of the data is underway. These results are in agreement with results obtained previously at the University of Saskatchewan, whereby pigs fed wheat and barley-based diets grew in a similar fashion.

IMPACT

Wheat has higher energy and protein contents than barley for swine, but the preliminary findings of this investigation bear out previous findings that growth of swine is similar with diets based on wheat and barley. Therefore there may be little or no benefit from the inclusion of wheat in grower diets for swine.

Table 1: Compositions of diets (%)

	GROWERS				FINISHERS			
Ingredients	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8
Wheat	-	78.9	-	-	-	80.0	-	-
Barley	-	12.07	84.73	88.22	-	13.2	90.9	94.2
Corn	78.0	-	-	-	83.7	-	-	-
Soybean meal (47%)	18.9	5.72	12.28	8.7	13.6	3.0	6.5	3.167
Dicalcium phosphate (Biophos)	1.22	1.19	1.09	1.14	0.82	0.79	0.68	0.73
Limestone	1.19	1.18	1.15	1.15	1.12	1.1	1.08	1.07
Salt (iodized)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Tallow	-	-	-	-	-	1.0	-	-
Lysine HCl	-	0.19	-	0.04	-	0.15	0.06	0.125
Vit/mineral mix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Analyses (%)								
Crude protein	16.3	16.2	16.0	14.8	14.4	14.1	14.7	13.0
DE (calculated)	3370	3370	3100	3092	3390	3390	3100	3092
Ratio DE/CP	207	207	194	209	239	239	214	238

Table 2: Effects on mean growth performance of growing pigs during the first 4 weeks

	Diet				Statistical significance of difference
	EW 1	EW 2	EW 3	EW 4	
Weight after 4 weeks, kg	43.9^{c}	39.8^{b}	39.5^{b}	36.0^{a}	P<0.001
Feed eaten per pig, kg	53.6	56.0	48.3	46.6	NS
Gain/feed ratio	0.43^{b}	0.35^{a}	0.42^{b}	0.37^{a}	P<0.05
DM digestibility %	83.3^{b}	79.8^{b}	70.6^{a}	72.1^{a}	P<0.01
CP digestibility %	75.6^{b}	77.6^{b}	63.7^{a}	60.3^{a}	P<0.001

LAND, AIR, WATER

STUDIES ON THE EFFICIENT UTILIZATION OF LIQUID HOG MANURE

L.A. McLean, L. Henry

ABSTRACT

Liquid hog manure was applied to established alfalfa at rates up to 16,000 gallons per acre and to barley at rates up to 8,000 gallons per acre with three separate placement techniques. Yield increases of approximately 960 kg/ha were measured on the barley experiment and 600 kg/ha on the alfalfa experiment. The liquid hog manure was found to contain 10 lbs. N, 2 lbs. P_2O_5 and 5 lbs. K_2O per 1000 gallons. These results were similar to those achieved in 1981 where the grain yield was increased by 500 kg/ha and the forage 700 kg/ha.

BACKGROUND AND OBJECTIVES

In Saskatchewan the majority of large hog operations are based on the liquid manure handling system for waste disposal. The efficiency of this waste material as a fertilizer product and the best method of handling the material in the field is not well understood. In order to determine the most efficient use of this material in the field this study, using continuous cropping of barley, was established. This material could greatly reduce the fertilizer input of individual farms and also be a source of potential income to the hog operators. One problem found on many farms in Saskatchewan is salinity. These areas must in many cases be sown to perennial forages which once established are difficult to fertilize efficiently. To determine the potential effect of liquid hog manure on salinity levels and production of a saline system rates of liquid manure were applied to alfalfa established on a saline gradient (slight salinity to severe).

In summary the objectives of this study are:

(i) to determine and quantify the effect of measured rates of liquid hog manure with known quantities of nutrients on the yield and quality of cereal grain production.

(ii) to determine the effect of liquid hog manure applications on the productivity of saline soils.

EXPERIMENTAL METHOD

To determine the two separate effects indicated above this section is presented as 2 separate experiments.

Experiment #1

Rates - 0, 2000, 4000, 8000 gallons per acre of liquid hog manure.

Placement Methods - inject, broadcast plus incorporate (tandem disc), broadcast and leave on the surface.

Plot Design - the plotitaflo treated Melvin was sown at a rate of 55 kg/ha. The area was sprayed on June 9 with a Stampede CM to control weed growth.

Experiment #2

This experiment involves strips 40 feet in design was a randomized complete block with four replications. The individual plot size was approximately one- half acre.

The manure was obtained from the Prairie Swine Centre located on the Goodale Farm. The approximate nutrient analysis of this material was N, 10 lbs./1000 gal. P_2O_5, 2 lbs./1000 gals. and K_2O, 5 lbs./1000 gal.

This material was spread on the test site Oct. 13-19/81 inclusive. These areas were then sprayed with 2,4-D to control winter annual weed growth.

These areas were tilled on May 1, and seeded to Melvin barley on May 4, 1982. The vwidth and 760 ft. long running east-west from a relatively non saline soil down into a stronly saline soil in the southwest corner of the half-section on which the Swine Centre is located. Treatments included rates of 0, 2000, 4000, 8000, and 16,000 gallons per acre of liquid hog manure all of which was applied as a surface broadcast application on the established alfalfa stand.

The liquid hog manure was applied Oct. 19/82

Alfalfa yield assessments were again made at six locations across the treatment strips using a Mott harvester. Two separate cuts were made on June 29 and Aug. 16. Total yield and quality is shown in Table 2.

Both these locations have been prepared for further plot work in 1983.

RESULTS AND DISCUSSION

The data collected from the two experiments is shown in Tables 1 and 2. A separate Table 3 shows the 2 years results of alfalfa forage yield from the saline site.

Table 1.

1982 HOG MANURE - BARLEY

	Rate gals./ acre	Emergence (Plants/m^2)	Seed Depth (cm)	Heights (cm)	Maturity (% Moisture)	Yield (kg/ha)
Inject	0	128	5	68	22	2144
	2,000	120	5	72	17	2825
	4,000	116	6	74	17	3089
	8,000	124	6	79	18	3396
Broadcast + Incorporated	0	108	8	71	22	2314
	2,000	104	6	71	20	2704
	4,000	104	6	73	19	2937
	8,000	108	8	74	16	3145
Broadcast	0	120	6	67	20	2466
	2,000	120	6	69	18	2717
	4,000	120	6	75	19	2970
	8,000	116	6	75	16	3274

Table 2.

1982 HOG MANURE - ALFALFA

Rate gals./acre	Dry Matter Yields (kg/ha) Cut 1	Cut 2	Total	% Protein Cut 1	Cut 2
0	2056	1534	3590	15.0	17.5
2,000	1925	1480	3405	16.9	15.6
4,000	2084	1594	3678	14.4	14.4
3,000	2550	1623	4173	15.6	15.6
16,000	2394	1776	4170	15.6	14.4

Table 3.

TOTAL ALFALFA YIELD (1981 & 1982)

Rate (gal/acre)	Dry matter yields kg/ha		
	1981	1982	Total
0	3400	3490	6990
2,000	3400	3405	6805
4,000	2210	3678	5888
8,000	4930	4173	9103
16,000	4080	4170	8250

The liquid hog manure increased the yield of Melvin barley by 960 kg/ha when 8,000 gal. of material was applied. This yield increase plus the earlier maturity as indicated by percent moisture and the increased plant height (8-10 cm) results in a very economic response from the manure.

Tables 2 & 3 show the response of alfalfa to liquid hog manure. In general an increase in forage of about 600 kg/ha has been achieved.

IMPACT

This study has shown to date that there is a significant economic value to liquid hog manure. 8,000 gal/acre gave a barley yield increase of 960 kg/ha. This added value can be used to increase production or to maintain high production levels but reduce fertilizer inputs. An approximate value based on nitrogen content alone would be $20.00/acre for the 8,000 gal rate. When using the yield increase of barley i.e. 960 kg/ha over the 0 level than the value based on $2.00/bushel barley would be $38.00/acre.

METHODOLOGY FOR RAPID MEASUREMENT OF FIELD MOISTURE

D.R. Cameron

ABSTRACT

The purpose of this study was to develop a soil moisture assessment method for use as a routine service by soil sampling agents. In initial field testing tensiometers and resistance block instruments were too slow; neutron and infrared techniques too expensive and the new time

domain reflectometry, dielectric measurements and passive microwave required more development. The moisture depth probe, direct electrical resistance and a hand rating system based on texture and feel were field tested in co-operation with seven Saskatchewan soil test agents. Within field the correlation between these measurements and actual moisture content was low as the measurement variability of the technique was greater than the moisture variability. Significant correlations were obtained over the whole population of fields. The depth probe showed the best correlation in heavier textured soils and appeared to be the simplest method. The hand rating system showed a significant correlation to moisture content after converting from field capacity to total moisture. This system showed the greatest potential for field moisture estimation and could be readily used by soil test agents. The microwave oven provided a very rapid and accurate method for moisture measurement during sample preparation. Estimating the total moisture from one or two air drying weight losses, tested on heavy clay soils, was too slow and subject to error. The Ohaus moisture balance was qualitatively tested and appeared to work on powdery or granular soils but would require the establishment of drying settings for routine use.

BACKGROUND AND OBJECTIVES

This project was designed to develop a method of rapid field measurement of soil moisture for use by core truck operators as a routine service to farmers and the Soil Testing Laboratory.

EXPERIMENTAL METHOD

The following methods for measuring or estimating moisture were tested: gravimetric; moisture depth probe; resistance blocks; tensiometers and hand texture and feel. In Phase I each instrument was tried on several fields and its ability to fulfill the primary objective was qualitatively assessed. In Phase II the three methods selected in Phase I (resistance meter, depth probe and hand texture and feel) were field tested in co-operation with seven soil testing agents. As well, three methods of measuring moisture content during sample preparation in the agent's shop were tested. These include weight loss after air drying (done prior to shipment to the lab), use of a microwave oven and use of the Ohaus moisture determination balance.

RESULTS AND DISCUSSION

Phase I - Initial Testing

As the emphasis in this phase was to determine the techniques' usefulness to the core truck operator, the speed and ease of conducting the measurement were the two main factors. The results of this testing are summarized below.

1) Gravimetric: This measurement using oven drying and weighing is the standard method. It is both time consuming and costly (a drying oven and accurate weighing balance are required).

2) Moisture Depth Probe: This is often used by farmers and agronomists for a quick measurement. The probe slides easily through moist soil until the dry subsoil is reached, giving a good indication of moisture depth. Its speed makes it suitable for rapid field measurement.

3) Resistance Blocks: This method uses gypsum or resistance blocks placed in contact with the soil. The moisture in the soil establishes an equilibrium with the blocks. The block's resistance to an electric current is related to the water absorbed. These are useful in the wilting point to field capacity moisture ranges but are too time consuming for rapid measurement.

4) Tensiometers: These, consisting of a pressure guage with a continuous column of water connected to a porous tip, measure the tension with which the water is held. Charts for various soil textures are used to convert the tension to moisture content. Tensiometers are not suitable for rapid measurement as the tips are easily broken, probing at several depths at each location is time consuming and they are not useful much below field capacity.

5) Hand Feel and Texture: Moisture content can be determined by the feel and appearance of the soil. This method is relatively fast and simple and easily adapted to field use.

6) Direct Soil Resistance: The soil's ability to pass on electric current increases with the moisture content. A resistance meter is easy to use and can be used directly in the field.

In summary, very few instruments are suitable for field use by soil test agents. However, the direct resistance meter, a hand rating system and the moisture depth probe offered speed and ease, and were selected for further testing.

Phase II - Field Testing

Seven core truck operators each examined two fields with 8 to 10 replicate cores taken per field. The results are summarized in Table I.

The meter readings (ohms) varied from 10 in wetter soils to 50 in drier soils. Within field variation was relatively large with coefficients of variation from 20 to 30%. The method used for estimating moisture by hand feel and appearance was obtained from the Irrigation Extension Branch, Outlook. The codes used were as follows:

Moisture Rating	Code	Soil Texture	Code
Field Capacity	4.0	Heavy Clay	10.0
75% Field Capacity	3.0	Clay	8.0
50% Field Capacity	2.0	Clay Loam	6.0
25% Field Capacity	1.0	Loam	4.0
Wilting Point	0.0	Sandy Loam	2.0

Soil texture was the least variable of the measurements. The hand texture did not vary appreciably between locations but it tended to be lower than the lab rating.

The hand rating system for moisture measurement ranged from less than 25% to greater than 100% field capacity with coefficients of variation between 15 and 25%. The probe measured the depth of moist soil ranging from 6" to 36". The coefficients of variation were low, from 10 to 20%. Within field correlations between the methods were generally not significant suggesting that each technique measures some different (unrelated) aspect of soil moisture.

Oven-dry soil moisture content was measured on the bulked samples from each field to determine the actual moisture content for comparison with the three tested methods. Correlations on individual sites were variable and should be interpreted cautiously due to small sample size. Correlations for the resistance meters improved with a larger site basis suggesting that moisture variation at each site was not great enough to establish a correlation trend but significantly correlated trends appeared over more extreme moisture differences.

Correlations within field between oven-dry and hand rated moisture contents were generally opposite so that larger groupings resulted in non-significant relationships. Converting the hand measurement from available to total moisture improved the correlation. The conversion requires knowledge of the soil physical properties (moisture content at field capacity and wilting point and bulk density) which is not always available. Data collected by Ayres et. al. (1973)[1] was used to derive approximate values of bulk densities and soil moisture retension properties for various depths and textures. These value were used to calculate moisture using field and lab textures. Field texture calculations tended to underestimate the measured moisture content while lab texture calculations overestimated it. Regression analysis indicated that both regressions were significant but accounted for only 25 to 32% of the observed variation.

[1]Ayres, K.W., Button, R.B. and de Jong, E. 1973. Soil morphology and soil physical properties. II. Mechanical impedance and soil moisture retention and movement. Can. J. Soil Sci. 53:9-19

The moist soil depth measured by the probe was significantly correlated to total moisture content (0-24") for heavier textured soils (clay loam to heavy clay) but not lighter soils. Over all soils, low correlations from 0.12 to 0.27 were obtained for the probe versus calculated total moisture.

Correlations between moisture content and the three methods were low on an individual site basis but significant relationships began to appear when all sites were used. Significant correlations were obtained between the three methods tested in the field (Table 2). None of the methods were completely satisfactory but all could be developed further. Although hand rating was the most complicated it was felt that a modified version of this offers the greatest potential.

Phase II - Other Methods

Air drying, use of a microwave oven for drying and an Ohaus moisture determination balance were examined as a means of measuring moisture content in the operator's shop.

The microwave oven took 8 to 30 minutes to dry a sample depending on the soil texture. Measurements were very similar to those obtained using conventional oven drying.The use of the microwave oven is acceptable and fast but operators must have a precise gram weighing balance.

When air dryed 56 to 82% of the moisture is lost within 48 hours. After 35 days at room temperature (18°C) 83 to 88% of the moisture was lost. Air drying was found to be too time consuming.

The Ohaus moisture determination balance operates on the theory that various materials have characteristic drying curves. Soil is placed on a scale under a heat lamp. From sample weights recorded a moisture loss curve is plotted. Characteristic drying settings for a variety of soil conditions would be required before agents could use this method.

IMPACT

As extended cropping and more extensive use of fertilizers increase, soil moisture will become a critical variable in decision making. More precise and efficient soil moisture measurement methods will be required.

Table 1. Summarized field results and variability for the meter reading, texture, hand rating and depth probe measurements obtained in Phase II.

Site	Depth	Meter[1] Reading	S.D.	Texture[2]	S.D.	Hand[3] Rating	S.D.	Probe[4] Depth	S.D.
G1	0-6	14.4	5.7	6.0	0.0	1.50	0.21	29.3	2.0
	6-12	13.8	4.3	6.0	0.0	1.75	0.25		
	12-24	14.8	4.4	8.0	0.0	1.86	0.31		
G2	0-6	16.9	3.1	6.1	0.4	1.44	0.18	28.3	3.3
	6-12	16.4	2.8	6.0	0.0	1.53	0.24		
	12-24	15.4	3.7	6.0	0.0	1.56	0.26		
E1	0-6	46.0	22.1	7.4	1.0	1.15	0.17	11.5	2.1
	6-12	32.7	7.9	7.4	1.0	1.10	0.34		
	12-24	34.8	6.9	7.6	0.8	0.88	0.27		
E2	0-6	45.0	9.7	7.6	0.8	1.08	0.29	5.6	2.0
	6-12	53.0	21.8	7.6	0.8	0.65	0.36		
	12-24	52.0	14.9	7.6	0.8	0.50	0.17		
SC1	0-6	-	-	6.0	0.0	2.75	0.76	12.3	5.8
	6-12	-	-	6.0	0.0	1.75	1.03		
	12-24	-	-	8.0	0.0	1.03	0.33		
SOU1	0-6	34.1	10.1	4.0	0.0	1.68	0.24	22.2	2.6
	6-12	34.5	9.6	4.0	0.0	1.70	0.26		
	12-24	31.1	6.8	5.4	1.9	1.60	0.38		
SOU2	0-6	27.1	4.3	4.0	0.0	1.75	0.20	28.2	4.0
	6-12	24.3	5.1	4.0	0.0	1.80	0.23		
	12-24	20.8	5.1	4.0	0.0	1.83	0.26		
LEM1	0-6	28.1	8.4	4.0	0.0	1.85	0.24	24.4	3.4
	6-12	27.5	10.0	4.0	0.0	1.85	0.58		
	12-24	22.8	6.2	4.0	0.0	2.05	0.44		
LEM2	0-6	18.9	2.8	4.0	0.0	1.65	0.24	20.8	3.9
	6-12	21.1	4.6	4.0	0.0	1.70	0.26		
	12-24	21.7	6.7	4.0	0.0	1.60	0.24		
FG1	0-6	15.5	6.6	6.0	0.0	3.90	0.31	36.0	0.0
	6-12	11.0	3.9	6.0	0.0	4.00	0.00		
	12-24	8.8	2.6	6.0	0.0	4.00	0.00		
FG2	0-6	10.8	1.4	6.0	0.0	3.85	0.34	36.0	0.0
	6-12	11.3	2.8	6.0	0.0	3.85	0.24		
	12-24	9.0	1.9	6.0	0.0	4.10	0.39		
SB1	0-6	44.5	5.0	2.0	0.0	3.93	0.17	22.3	4.2
	6-12	41.6	5.2	3.0	0.0	3.75	0.42		
	12-24	41.5	8.2	4.0	0.0	2.95	0.50		
SB2	0-6	41.0	4.6	3.0	0.0	4.00	0.00	20.8	8.8
	6-12	34.9	9.6	3.0	0.0	4.00	0.00		
	12-24	42.0	7.9	4.0	0.0	3.50	0.72		

1. Meter readings in Ohms
2. See texture classification in text
3. See hand rating in text
4. Probe depth in inches

Table 2. Correlations between the various field moisture measurement methods and actual moisture content.

Sites	Moist. vs. Meter Readings	Moist. vs. Ave. Hand Rating	Moist. vs. Bulk Hand Rating	Moist. Vs. Ave. Probe Depth
[1]Heavy Textured Soils	-.45	.37	.38	.85*
[2]Light Textured Soils	-.51*	-.40	-.44	-.14
All Soils	-.51*	-.04	-.06	.27
All Soils	Moist vs. Converted Hand Rating .57	Resistance vs. Probe Depth .87	Hand Rating vs. Probe Depth .95	

[1]Included G1, G2, E1, E2, SC1, FG1, FG2
[2]Included SOU1, SOU2, LEM1, LEM2, SB1, SB2

MICRONUTRIENT STATUS AND TRANSFORMATIONS IN SASKATCHEWAN SOILS

R.E. Karamanos and J.J. Germida

ABSTRACT

Soil types (sands, eroded soils, organic soils) and areas in the province of Saskatchewan (primarily NE and NW Saskatchewan and Outlook irrigation area), where micronutrient deficiencies are possible, have been delineated through a preliminary exploratory survey of crop responses in 1982. Benchmark sites have been established in certain areas to monitor responses to micronutrient fertilization and micronutrient fertilizer residual effects.

Four extractants, DTPA, EDTA, 1N NH_4OAc and 0.1 N HCl evaluated on the basis of their ability to predict Zn and Cu deficiencies using nine Saskatchewan soils and alfalfa as a test crop. The DTPA test was found to be most suitable as an index of Zn deficient soils with a "critical" value for Zn deficiency of 1.1 ug/g of soil. The results obtained for Cu were inconclusive.

BACKGROUND AND OBJECTIVES

Research on the micronutrient fertility status of Saskatchewan soils is limited because "available" micronutrient levels have generally been considered adequate for crops grown in most of the province's soils.

This project was therefore initiated to identify areas in Saskatchewan with potential micronutrient defiencies and to evaluate the response of various crops to micronutrient applications. A preliminary study has been conducted to evalutate criteria for detecting micronutrient deficiencies in the soils of our province. The long-term objectives of this project are to understand the chemical and microbiological behaviour of micronutrients that lead to their deficiencies and provide a testing criteria for identifying these deficiencies and guidelines for their correction.

EXPERIMENTAL METHODS

Field Experiments

A total of 79 treatments of micronutrient fertilization were applied at 36 sites selected in 18 areas of Saskatchewan. There were five sites at Aylsham; four at Carrot River; three at each of Outlook, North Battleford, and Regina; two at each of Choiceland, Kyle, Canora, Saskatoon, and Gull Lake; and one at each of Tisdale, Waldheim, Kindersley, Glen Bain, Englefeld, Cutknife, Viceroy, and Lucky Lake. The selection criteria were based primarily on information from the Saskatchewan Soil Testing Laboratory and secondly on information from Agricultural Representatives with Saskatchewan Agriculture and fertilizer company representatives. The test crops were spring wheat at twenty sites, barley at five sites, alfalfa, canola, lentils, and peas at two sites each, and corn, flax, and winter wheat at one site each.

Two types of sites were established. At the "demonstration" sites, various types of micronutrient fertilizers (Zn, Cu, and B) were applied without replication to 2,000 ft^2 (186 m^2) plots. At the "detailed sites", micronutrients (Zn, Cu, B, and Mn) were applied to 400 ft^2 (37 m^2) experimental plots with treatments duplicated. Variables were the rates, methods of placement, and chemical forms of the micronutrients applied.

For the broadcast and incorporated experiments, the following fertilizer rates were applied: 10 kg Zn/ha, 5 kg Cu/ha, 30 kg Mn/ha, and 2.5 kg B/ha. For the seed-placed experiments, rates of 2 and 4 kg/ha of each micronutrient (2 kg/ha only for B) were applied in a mixture with ammonium phosphate supplying 25 kg P_2O_5/ha. The rates for foliar application were 0.3 kg Zn/ha and 0.22 kg Cu/ha per application.

The micronutrient fertilizers applied on the demonstration sites were MICROMATE™(1) ZINC 180 for Zn, MICROMATE ™ COPPER 155 for Cu, and shelf-chemical borax ($Na_2B_4O_7.10H_2O$) for B. In addition to the above forms, shelf-chemical $ZnSO_4$, ZnO, $CuSO_4$, and CuO were included at the detailed sites. Foliar Zn and Cu were applied as THIS ™ ZINC and THIS™ COPPER, respectively.

Soil samples obtained from all sites were analyzed for 0.5 M $NaHCO_3$-extractable NO_3-N, inorganic P and K, 0.001 M $CaCl_2$-extractable SO_4-S, DTPA-extractable Zn, Fe, Mn, and Cu, NH_4OAc-extractable B, and a number of other physical and chemical properties using methods employed by the Saskatchewan Soil Testing Laboratory.

Square meter yield samples were obtained in duplicate or triplicate (for larger plots) from all of the experimental plots. The straw and grain were separated (when applicable), and dry matter yields of each were determined.

Growth Chamber Experiment

Nine surface soil samples were selected on the basis of a preliminary assay with the DTPA-TEA extractant from the pool of soil samples collected from the thirty-six locations at which field trials were conducted.

A growth chamber experiment was carried out to select and calibrate soil tests for determining "available" Zn and Cu.

The treatments applied consisted of a control, a 5 ug Zn/g of soil and a 2.5 ug Cu/g of soil treatment, respectively. Adequate concentrations of macronutrient elements were applied to all treatments to maintain optimum growth. The test crop was alfalfa (*Medicago sativa* cv. Beaver). Eight alfalfa seeds were sown in each pot. The pots were placed in a growth chamber in a completely randomized block design with two replicates. Seedlings were thinned to four plants per pot two weeks after emergence. Three harvests of alfalfa were taken when the majority of alfalfa plants were at the 1/10-bloom stage.
"Available" Zn and Cu concentration in each soil sample was determined by four different extracting methods, namely (i) DTPA-TEA (pH 7), (ii) EDTA-$(NH_4)_2CO_3$ (pH 8.6), (iii) 0.1 N HCl, and (iv) 1 N NH_4OAc (pH 7.0).

RESULTS AND DISCUSSION

Field Experiments

An exploratory survey of yield responses to micronutrient fertilization was carried out during the first year of this program (1982). This study reveals that areas of possible concern include sandy and eroded soils, calcareous soils, and soils where intensified production practices (such as irrigation) are followed. Although this year's program did not include organic soils (peats), visual symptoms of Cu and Mn deficiencies have been observed in crops growing on such soils. Therefore, areas with organic soils will be included in next year's program.

The extent of micronutrient deficiencies in Saskatchewan is not known. However, it appears for the most part that they may be associated with either sandy and/or organic soils of which significant acreages exist within the province.

Some of the micronutrient fertilizers contain sulphur as well as small quantities of other micronutrients. There were a number of cases in this year's program where responses to soil applied micronutrient fertilizers were a result of the sulphur component of the fertilizer rather than the micronutrient itself. The farmer has to consider that this is a very expensive form of sulphur in situations where the micronutrient component is not required.

Some micronutrient toxicity effects were observed at a few sites where application rates exceeded the recommended level for the placement method used. This indicates the importance of using correct rates and methods of placement, and the data obtained indicates that micronutrients should not be applied indiscriminately to soils in Saskatchewan.

Growth Chamber Experiment

The DTPA-TEA test was found to be the most suitable extractant as an index of "available" zinc in soil. It separated deficient from non-deficient soils, provided an indication of the supplying power of soil Zn, and afforded an index of the plant "available" labile pool in the soil.

Although significant correlations between extractable Cu and either relative yield or plant uptake were obtained in certain cases, separation of Cu responsive from non-responsive soils was not possible for any of the soil tests.

"Crtitical" level obtained with the DTPA extractant for Zn was 1.1 ug/g. Soil criteria for the determination of the "critical" level for Cu were inconclusive.

IMPACT

Micronutrients are elements which are essential to plant growth, but required by plants in relatively low amounts. Suggestions of micronutrient deficiencies in Saskatchewan and the limited amount of information available have dictated the need for extended study on the status and transformations of micronutrients in the soils of this province.

It is hoped that this study will aid in the development of a sound micronutrient fertilization program (including appropriate soil testing techniques) for the areas in this province, where micronutrient deficiencies do occur.

ENERGY, EQUIPMENT

ENERGY-DEEP TILL DISCER SEEDER

W.B. Reed

ABSTRACT

A pneumatic seeding attachment added to a MF No. 36, 15 foot wide machine was used to permit deep tillage, deep banding of fertilizer and seeding at normal depths while applying Avadex BW for wild oat control. Field trials during 1982 indicated seeding depths of 43 mm and 16 mm with wheat and canola respectively as compared to 47 mm deep when seeding wheat with a conventional discer and 20 mm with a double disc drill. The average yield of wheat with the Deep Till Discer was 3411 kg/ha compared to 3182 kg/ha with a conventional discer, but there was no statistical difference in yield. There was relatively poor establishment of the Canola crop with the discer seeder, partly atributable to deeper and less uniform placement of the seed. Heavy infestations of broad-leaved weeds reduced yields with the discer seeding yielding about one-half that of the drill seeded plots.

BACKGROUND AND OBJECTIVES

The discer-Seeder as presently used tends to place seed too deeply if operated for maximum control of weeds such as wild oats. Seeding deeper than 50-60 mm tends to reduce yield of cereal crops, while this depth is too deep for small seeded crops such as Canola, thus eliminating the benefits of the once-over operation of the discer seeder possible in both stubble and summerfallow cropping.

The benefit of deep-banding of fertilizer requires a separate field operation either in the fall or spring. Such operations can partially destroy a good seed-bed and contribute to loss of soil moisture and increase the potential for soil erosion, as well as requiring more energy and labor cost.

The objectives of this project is to modify the discer and its function to permit deeper tillage for weed control, to provide deep banding of fertilizer while maintaining a shallow seed placement. The discer can also incorporate shallow placed soil applied herbicides. Therefore the modifications can result in a seeding machine capable of good weed control, deep banding of fertilizer, seeding and herbicide application in the spring with one operation in either stubble or summerfallow fields.

This project relates to reduced energy consumption and reduction in tillage as well as fertilizer and herbicide application and seeding in difficult conditions. The expected economic returns are difficult to predict, however a reduction of one operation in field work could result in a saving of $1.00 per acre. An increase in yield of 2% could result in a return of $2.00 to $3.00 per acre. If applied to only 1/4 of the cropped acreage in Saskatchewan the total benefit could reach $30

million. The expected benefits from reduced tillage and yield increase are conservative and no attempt has been made to evaluate the other possible benefits cited. Present practices with rapeseed production require herbicide application, two fall incorporation operations, a spring tillage operation followed by either separate fertilizer application or a combined fertilizer and seeding operation.

EXPERIMENTAL METHOD

Machine modifications: A larger capacity fan for improved air delivery was obtained and incorporated into the pneumatic seed delivery system. The pneumatic hoses were replaced with larger diameter and more durable hose material. These changes were necessary to maintain constant seed delivery even though the fan speed was reduced about 30% due to a reduction of the tractor engine speed.

Field Experiments: Replicated plots 61 m long and 10 m wide were seeded during 1982 on the Kernen Research Farm at Saskatoon and compared to plots seeded with conventional methods.

Neepawa wheat was seeded May 12th with the Deep-Til discer seeder and a John Deere conventional discer seeder. Canola was also seeded with the Deep-Til discer seeder but for comparison an I.H. double-disc opener drill was after pre cultivating in lieu of the John Deere discer.

Liquid Avadex BW for wild oat control was applied through a rear-mounted spray boom while seeding the Deep-Til discer seeder. A post-seeding application of Avadex BW was made on plots seeded with the John Deere discer and the I.H. drill.

All plots were harrowed and packed following the herbicide application.

Post-emergence control of weeds in the wheat plots was effected by the application of Glean at the rate of 30 g per hectare. Poast was applied to the Canola plots to control volunteer cereals.

All required fertilizer was applied at a time of seeding with the Deep-Til discer seeder and included a mixture of 98.5 kg/ha of 34-0-0 and 100 kg/ha of 27-27-0. Conventionally seeded plots received 160 kg/ha of 34-0-0 broadcast before seeding, followed with 54.5 kg/ha of 11-51-0 applied with the wheat seed and 109 kg/ha of 27-27-0 applied with the Canola seed.

The depth of tillage and the depth of the seed was determined within each plot.

The plant population was also determined for all plots.

The grain yield of all plots was measured during harvest on August 19, 1982 and September 17, 1982 for the Canola and wheat respectively.

RESULTS AND DISCUSSION

Plant Population and Seed Depth

DEEP-TIL DISCER VS CONVENTIONAL SEEDING TRIALS 1982

DATES: SEEDING, MAY 12 SPRAYING, JUNE 29
SEED RATES: WHEAT, 85 KG/HA CANOLA, 7 KG/HA
FERTILIZER: 60 KG/HA OF N 55 KG/HA OF P
CHEMICALS: 3.5 L/HA AVADEX BW & 100 L/HA WATER
30 G/HA GLEAN & 165 L/HA WATER (WHEAT)

WHEAT

PLANT COUNT / SQ M			SEED DEPTH (mm)		
	CON*	PNU*		CON	PNU
AVE	236	196	AVE	47	43
C V**	27%	20%	C V	27%	42%
CHANGE WITH PNU - 17%			CHANGE WITH PNU - 9%		

CANOLA

PLANT COUNT / SQ M			SEED DEPTH (mm)		
	CON	PNU		CON	PNU
AVE	72	56	AVE	20	16
C V	32%	42%	C V	38%	56%
CHANGE WITH PNU - 22%			CHANGE WITH PNU - 20%		

Plant counts and seed depths were taken at three places in each of the four replicates of each treatment. The averages are of the 12 samples of each treatment.

* CON - conventional discer
PNU - Deep-Til discer
** C V - coefficient of variations

Grain Yield

Wheat Yield - kg/ha

	Conventional	Deep-Til Discer
Ave.	3182	3411
C.V.	0.10	0.14

NOTE: Not significantly different at 0.05.

Canola Yield - kg/ha

	Conventional	Deep-Til Discer
Ave.	893	438
C.V.	0.30	0.50

Seeding Depth: The depth that the wheat was planted was 5 mm shallower with the Deep-Til discer seeder and was more variable in depth. The placement of Canola was similar, being 4 mm shallow but with a wider range of depth.

Plant population: The number of wheat plants emerging was 17% less with the Deep-Til discer than with the conventional discer and 22% less when seeding Canola. The Canola plant stand was not as uniform as with the conventional drill seeding, but poor stands were obtained with both methods.

Growing conditions: Moisture conditions were good during near all of the growing season, but a heavy snowfall on May 28, 29 after crop emergence had an adverse effect on the growing crop. The low plant population of Canola was caused to some extent by the cold and wet conditions.

Yields: The low plant population of Canola accompanied by heavy infestations of broad-leaved weeds caused the low yields. The yield from conventional drill seeding of Canola was about double that obtained from the Deep-Til discer.

The wheat yields obtained were about equal with both methods of seeding, although a higher average yield was obtained with the Deep-Til discer seeder. A delay of about 2 days in plant development was noted throughout the entire season on those plots seeded with the Deep-Til discer seeder.

IMPACT

The use of a discer converted to act as a Deep-Til discer with deep placement of fertilizer results in yields of wheat about equal to that of conventional discer seeding in 1982. Further trials are required to confirm this result and to evaluate under less ideal conditions.

The success of seeding Canola with the Deep-Til discer into stubble may be dependent on the ability to control weeds. Lack of control of broad-leaved weeds found in many stubble fields will prohibit growing Canola without additional control methods that will require additional tillage operations.

EVALUATION AND COMPARISON OF THE SPINNING DISC (CDA) AND LOW PRESSURE NOZZLES WITH CONVENTIONAL FLAT FAN NOZZLES

D.G. Pchajek and D.C. Campbell

ABSTRACT

Three replicated small plot experiments were conducted in two seasons to evaluate the efficacy of diclofop methyl, bromoxynil/MCPA, 2,4-D,

DPX4189, paraquat and glyphosate when applied with TeeJet 8002, 8002LP, 8001 and CDA nozzles. In addition the mechanical reliability of the CDA was evaluated. For in crop weed control, diclofop methyl, 2,4-D, bromoxynil/MCPA and DPX4189 all provided the best overall control when applied with Teejet 8002 or 8002LP nozzles. In chemical fallow TeeJet 8002 or 8002LP nozzles provided paraquat with the greatest efficacy on a broad spectrum of weeds. The results with glyphosate were more variable. Reduced water volume (8001 or CDA) had little effect on efficacy. If herbicide rates were reduced, TeeJet 8001 nozzles were superior to the CDA. With all herbicides tested in no case was the CDA superior to currently recommended hydraulic nozzles. Mechanical performance of the CDA was found to be adequate. However, more care is required in the day to day operation and maintenance of the CDA units.

BACKGROUND AND OBJECTIVES

A prerequisite to the safe and cost efficient application of herbicides is good equipment. Although, current high pressure nozzle systems are adequate, a modified nozzle (Low Pressure) and a radical new design (the Spinning Disc) offer potential advantages. The low pressure (LP) nozzle offers a reduction in the amount of chemical drift. The Spinning Disc, also known as the Rotary Atomizer or Controlled Droplet Applicator (CDA), is claimed to produce less drift and require less chemical and water to produce the desired weed control. This project was initiated to evaluate the efficacy of a range of herbicides when applied through these new nozzle systems and to make comparisons with that obtained with the standard flat fan nozzles. Since the CDA is a radical new innovation we hope to evaluate the longevity and mechanical reliability as well as herbicide efficacy.

EXPERIMENTAL METHOD

A. Herbicide Efficacy

Three separate experiments were conducted in both 1981 and 1982 to evaluate selected broadleaf herbicides, products for chemical fallow, and diclofop methyl. Each experiment was designed as a randomized complete block of six metre by six metre plots replicated three times. Parameters evaluated included:

1. Water Volume
   a) standard volume - TeeJet 8002 and 8002LP nozzles
   b) half standard volume - TeeJet 8001 and CDA
2. Droplet Size
   a) Standard TeeJet 8002
   b) low pressure TeeJet 8002LP
   c) CDA (spinning disc nozzles)

3. Herbicide rates

Both recommended rates and half the recommended rates of each herbicide were applied through 8001 and spinning disc nozzles.

All treatments were applied with a six metre boom field sprayer equipped with separate booms for low pressure, standard, and spinning disc nozzle systems. To evaluate the effect of water volume the standard 8002 nozzles were replaced wiht 8001 nozzles. For the low pressure and standard nozzles the spacing and height were set in accord with current recommendations. For the spinning discs, three units were set at a height of 28 cm and spaced 1.8 metres apart. These nozzles were tilted 15 degrees backward in 1981 as recommended by the manufacturer. In 1982 this angle was reduced to seven degrees. The centre disc was set back from the boom to provide sufficient clearance for the spray pattern. A speed of eight kmph was used for the application of all treatments. The CDA units were operated at 2000 rpm and a flow rate of 1 litre/minute.

In the diclofop methyl experiment in 1981 Neepawa wheat was seeded on May 24. Spraying was conducted on June 16. At this time the crop was in the 3-5 leaf stage, wild oats were at 3-5 leaf, and green foxtail was at the 1-2 leaf stage. The crop was harvested on August 31. In 1982 seeding occurred on May 15. Spraying was conducted on June 11 with Neepawa wheat at 3-5 leaf, wild oats at 3-4 leaf, and green foxtail at the 3 leaf stage. The crop ws harvested on September 8.

In the broadleaf experiment in 1981, Neepawa wheat was seeded on May 30. Spraying occurred on June 17 wth the crop at 4-5 leaf and the majority of broadleaf weeds at the cotyledon to 2 leaf stage. Havesting occurred on August 26. In 1982 the crop was seeded on May 25 and harvested on September 9. The spray operation was conducted on June 21 with the crop at the 3-4 leaf stage. Broadleaf weeds ranged from 2-4 leaf.

In 1981 the chemical fallow experiment was sprayed on June 11. Spraying was delayed until weeds were relatively mature forming a canopy ranging up to 20 cm in height. In 1982 spraying was conducted on June 11 with the majority of weeds at a similar stage to that in 1981.

Weed control was visually assessed in all experiments, in both years, using the weed control rating scale (0-9) as outlined by the Expert Committee on Weeds. Similarly crop tolerance was rated by the standard 0-9 scale. Yield data was collected in the broadleaf and diclofop methyl experiments.

B. Mechanical Reliability and Dust Tolerance of the CDA Units

Throughout the course of the above experiments notes were maintained on any mechanical problems or operational inconsistances associated with the CDA nozzles. In addition a field experiment was conducted in 1982 to evaluate the effect of dusty operating conditions on the operation, output and pattern of the CDA nozzle system. In this experiment two spinning disc nozzles (CDA) were mounted on a six metre Co-op cultivator. Each was mounted such that it was 30 cm above the ground and set at an

angle of 15 degrees forward. A 130 litre water tank was mounted on the cultivator above the CDA units to allow water to flow to the discs by gravity. A number 55 orifice plate was installed in the feed lines to control the flow rate. Each CDA was connected to the electrical system of the tractor and operated at 2000 rpm, producing a flow rate of 0.5l/min. The cultivator equipped with these operational units was then used in the day to day cultivation of our fallow blocks so that extreme dusty conditions would be realized. Prior to initiation of this experiment these spinning discs were sent to Mr. Bill Reed, Agricultural Engineering Department at the University of Saskatchewan for pattern and output evaluation. At the commencement of the experiment the units were sent to be re-evaluated.

RESULTS AND DISCUSSION

A. Herbicide Efficacy

Diclofop Methyl (Hoe-Grass)

Herbicide efficacy and crop tolerance data collected in 1981 is presented in Table 1. Treatment 4 was sprayed later than the other treatments at a time when grassy weeds were beyond the desired leaf stage. Diclofop methyl offered excellent control of wild oats and green foxtail at all other rates and methods of application. Some variability in speed of herbicide activity and final control attained is evident and indicative of possible decreased control with some treatments under higher weed pressure.

Data collected in 1982 indicated that the low population of wild oats present was completely controlled by all treatments (Table 1). However, green foxtail control varied with the type of nozzle, herbicide rate, and water volume used. Only the standard 8002 and 8002LP nozzles provided acceptable control. A reduction in herbicide rate with the 8002 nozzle resulted in decreased control. If the water volume was reduced with either the 8001 or CDA nozzles a reduction in green foxtail control resulted. When both the herbicide rate and water volume were reduced the reduction in control wasn't as severe.

In both years Neepawa wheat showed complete tolerance to diclofop methyl regardless of the nozzle type, herbicide rate, or water volume used. In 1981 hail resulted in the loss of meaningful yield results. In 1982 all differences in yield were nonsignificant, reflecting a highly competitive crop stand and moderate weed numbers.

Broadleaf Weed Control

In both years 2,4-D, DPX4189 (Glean) and bromoxynil/MCPA (Buctril M) were the broadleaf herbicides selected for evaluation. Broadleaf weeds present in 1981 included; wild mustard, wild buckwheat, green smartweed, lamb's quarters and stinkweed. Weed control and crop tolerance data collected in 1981 and 1982 is presented in Table 2.

2,4-D

In 1981 a rain occurred two hours after the application of 2,4-D and reduced efficacy. In 1982 wild mustard was the only 2,4-D susceptible weed present in the experiment. When applied through 8002 or 8002LP nozzles 2,4-D provided acceptable wild mustard control. Reduction in water volume (8001 or CDA) and/or herbicide rate reduced the degree of control attained with 2,4-D.

Bromoxynil/MCPA

Results collected in 1981 indicated that good control of all broadleaf weeds evaluated was obtained with bromoxynil/MCPA at all rates, water volumes, and methods of application. Some variability in control was evident. The best overall control was obtained with recommended rates and standard 8002 nozzles. The 8002LP nozzles provided excellent initial control. Some recovery of wild buckwheat was evident with this treatment indicating slightly reduced control relative to 8002 nozzles. A reduction in the water volume used, whether applied with 8001 or CDA nozzles, decreased the degree of control attained. If the herbicide rate was reduced to a half, 8001 and CDA nozzles both provided less control than standard rates and water volumes. The 8001 nozzles seemed superior to the CDA nozzles with this low rate of herbicide although differences were small.

In 1982 there was more variablility evident with bromoxynil/MCPA both between nozzles and between weed species. Control of wild mustard was complete with the 8002 or 8002LP nozzles. 8001 nozzles gave excellent control at both full and half rates while CDA nozzles provided excellent control with the recommended rate, but only acceptable control when the rate was reduced. Control of wild buckwheat was excellent with 8002LP or 8001 (at half rate) nozzles. Acceptable control was obtained with 8002, 8001 (full rate) and the CDA at full rate. Half the recommended rate when applied with the CDA did not give acceptable control. For control of red root pigweed the best control was obtained with 8002 or 8002LP nozzles at full rates or 8001 nozzles at half the recommended rate. The CDA did not provide acceptable control when half the recommended herbicide rate was used.

DPX4189 (Glean)

In 1982 DPX4189 provided complete control of all broadleaf weeds evaluated at both full and half recommended rates regardless of the nozzle type used. At the lower water volumes DPX4189 was slower to produce the desired effect. In 1982 the rate of DPX4189 used was reduced to 11 g ai/ha (high rate) and five g ai/ha (half rate). DPX4189 did not provide acceptable wild buckwheat control at either rate, however 8002 and 8002LP nozzles gave the best suppression. No difference was apparent between treatments for wild mustard control. Red root pigweed was controlled by all treatments although 8002 and 8001 (at half rate) nozzles seemed superior.

Crop tolerance to all herbicides was excellent in both years.

Chemical Fallow

In both years paraquat (Sweep) and glyphosate (Roundup) were evaluated for weed control in fallow. In the first year glyphosate was applied with and without a surfactant. In the second year a surfactant was used with all glyphosate treatments. In each year the herbicide application was delayed until a distinct layering of weed growth was evident. In 1982 the predominant weeds were; dandelion, flixweed, wild buckwheat, narrow leaf hawk's beard, lamb's quarters, wild oats, and green foxtail. In 1981 wild oats, dandelion, narow leaf hawk's beard, and lamb's quarter were evident. Table 3 and Table 4 illustrate the weed control contained in 1981 and 1982.

Paraquat

Weed control was not acceptable with paraquat in 1981 regardless of the nozzle evaluated. The efficacy was highest when 8002 or 8002LP nozzles were used. In 1982 more variability was evident with weed species. Dandelion control was inadequate with all treatments. Only 8002 or 8002LP nozzles provided acceptable control of flixweed or green foxtail. For wild oat control all nozzles produced acceptable paraquat efficacy although 8002 or 8002LP were superior. For all weeds present in both years any reduction in water, whether applied through the CDA or 8001 nozzles, resulted in a marked decrease in the efficacy of paraquat.

Glyphosate

Results collected in 1981 indicated that a surfactant was necessary with glyphosate when the volume of water and/or rate of herbicide was reduced. In 1982 a surfactant was used with all applications of glyphosate. In 1981 glyphosate demonstrated the greatest efficacy when applied with 8001 or 8002LP nozzles although all differences were small. Reducing the water volume (8001 or CDA) resulted in very little reduction in weed control. Similarly reducing the herbicide rate had a very small effect on weed control through either the 8001 or CDA. In 1982 again water volume showed little effect on glyphosate efficacy, even with the dense stand of weeds evident at the time of application. If the water volume and herbicide rate was reduced the 8001 nozzles appeared superior to the CDA.

B. Mechanical Reliability and Dust Tolerance of the CDA Units

Observation on the general performance of the CDA units indicated few problems in general operation during the course of the efficacy tests. Two problems were noticed however. Any slight sideways tilting of one of the CDA units on the boom dramatically reduced the overlap of the spray pattern resulting in heavy coverage on one side and poor coverage on the opposite side. In addition any sudden jolt to the sprayer would interupt

the flow of liquid from the units. Since the pattern of each unit is so large a corresponding large patch of poor coverage would result. This wasn't a serious problem providing that spray speeds were kept within normal limits (8 kmph).

Initial pattern testing results for the dust tolerance test are presented in Table 5 as well as the testing parameters used for each of the two CDA units.

Some problems were apparent with these units in the field. After four hours of operation in the field the centre bolt of CDA #2 loosened and the unit had to be stopped for repair.

After 7.5 hours both units were sounding noisy. At 10.5 hours of operation CDA #1 stopped rotating and CDA #2 was sounding very gritty. At this time the units were removed, dismantled, and serviced. Both units were then remounted on the cultivator. Neither operated properly at this time as both needed manual assistance to start and rotated slower than previously. After two additional hours of operation both units were sent to Saskatoon for final pattern evaluation (Table 6).

Operation of the units under dusty conditions resulted in a reduction in speed of rotation when the same voltage and wire length as used in the initial test were used again. This indicates an increase in the resistance within each CDA which can be attributed to damage to the bearings of these units. The reduction in RPM resulted in a decreased volume of output (10.5 and 9.1% for units #1 and #2 respectively). In addition the width of the spray pattern from each unit was reduced, decreasing the overlap between patterns. The dusty conditions had not altered the spray pattern distribution of the units. This indicates that little wear had occurred in the plastic components. The main damage due to dust seemed to be due to it entering the top bearings. Newer Micromax CDA units are equipped with an upper shield which would likely decrease this problem.

IMPACT

TeeJet 8002 nozzles provided the most consistant weed control with a wide range of herbicides and under variable parameters of application. TeeJet 8002LP nozzles performed very well in most instances. The reduced drift associated with low pressure nozzles offers a potential advantage. These nozzles warrant further evaluation with a wider range of herbicides and under variable environmental conditions and parameters of application to test for consistency of results.

The Controlled Droplet Applicator did not live up to our expectations. Although the potential exists for application of reduced water volumes with the CDA, in most cases the degree of control was decreased when compared with standard water volumes. the TeeJet 8001 nozzle also offers reduced volume application, and in no case did the CDA provide superior

Table 1: The effect of nozzle type, rate of chemical, and water volume on crop tolerance and efficacy of diclofop methyl in 1981 & 1982

					Rating (Score 0-9)											
					June 24, 1981			July 8, 1981			June 24, 1982			July 8, 1982		
Treatment No.	Rate (kg/ha)	Nozzle Type	Volume (l/ha)	Pressure (kpa)	Wild Oats	Green Foxtail	Crop	Wild Oats	Green Foxtail	Crop	Wild Oats	Green Foxtail	Crop	Wild Oats	Green Foxtail	Crop
1.	0.7	8002	110	280	7.3	7.0	9	8.7	8.0	9	8.3	8.0	9	9.0	7.0	9
2.	0.35	8002	110	280	7.0	7.0	9	8.7	8.3	9	7.7	7.3	9	9.0	6.3	9
3.	0.7	8001	55	280	7.8	7.3	9	9.0	9.0	9	8.0	4.7	9	9.0	5.7	9
4.	0.35	8001	55	280	- *	- *	-*	6.7*	6.3*	9*	7.7	6.0	9	9.0	6.7	9
5.	0.7	CDA	45	140	7.3	7.7	9	9.0	8.3	9	8.3	6.3	9	9.0	5.0	9
6.	0.35	CDA	45	140	7.0	6.6	9	8.0	8.0	9	8.7	6.3	9	9.0	6.7	9
7.	0.7	8002LP	110	140	7.7	7.3	9	9.0	9.7	9	8.7	8.3	9	9.0	7.0	9
8.	-	-	-	-	0	0	9	0	0	9	0	0	9	-	-	9

* Treatment 4 sprayed 10 days after other treatments

Table 2: The effect of nozzle type, herbicide rate, and water volume on crop tolerance and efficacy of 2,4-D, bromoxynil/MCPA, and DPX 4189 in 1981 & 1982

						Rating (Score 0-9)											
						July 7, 1981			July 27, 1981			July 7, 1982			July 16, 1982		
Treat No.	Herbicide	Rate (kg/ha)	Nozzle Type	Volume (l/ha)	Pres. (kpa)	Wild Bwht.	Green S.Weed	Crop	Wild Bwht.	Green S.Weed	Crop	Wild Bwht.	Wild Mustard	R-Root P-Weed	Wild Bwht.	Wild Mustard	R-Root P-Weed
1.	2,4-D	0.35	8002	110	280	4.7	6.0	9	5.7	7.3	9	5.7	7.8	4.3	3.3	7.0	4.3
2.	Bromox/MCPA	0.56	8002	110	280	9.0	9.0	9	8.7	8.7	9	7.7	9.0	8.3	7.7	9.0	9.0
3.	DPX4189	0.02	8002	110	280	8.3	8.0	9	8.7	9.0	9	5.7	9.0	7.7	6.6	9.0	8.0
4.	2,4-D	0.35	8001	55	280	4.3	5.7	9	5.3	6.7	9	1.3	2.3	2.0	1.0	2.3	2.0
5.	Bromox/MCPA	0.56	8001	55	280	8.3	8.7	9	8.0	8.3	9	7.0	8.7	6.0	7.3	8.3	6.7
6.	DPX4189	0.02	8001	55	280	7.3	8.0	9	9.0	9.0	9	5.7	9.0	7.7	5.3	9.0	7.3
7.	2,4-D	0.18	8001	55	280	4.6	5.3	9	5.3	6.0	9	2.7	5.3	4.0	2.3	5.7	3.7
8.	Broxom/MCPA	0.28	8001	55	280	8.0	8.7	9	8.3	9.0	9	7.7	8.7	5.3	8.0	8.7	8.3
9.	DPX4189	0.01	8001	55	280	9.0	9.0	9	8.7	8.7	9	5.0	9.0	8.0	5.3	9.0	8.7
10.	2,4-D	0.35	CDA	45	140	2.7	3.7	9	5.3	6.3	9	1.0	3.0	4.0	1.0	3.0	3.0
11.	Bromox/MCPA	0.56	CDA	45	140	8.0	8.0	9	7.7	8.3	9	7.0	8.7	6.7	7.3	8.0	7.7
12.	DPX4189	0.02	CDA	45	140	5.7	6.7	9	8.7	8.7	9	4.7	8.3	8.0	4.0	9.0	7.0
13.	2,4-D	0.18	CDA	45	140	4.0	5.3	9	5.0	6.0	9	0.3	3.7	3.7	0.3	3.3	3.3
14.	Bromox/MCPA	0.28	CDA	45	140	7.0	7.0	9	8.3	9.0	9	5.0	7.3	6.0	5.0	7.3	6.0
15.	DPX4189	0.01	CDA	45	140	8.3	8.3	9	8.0	9.0	9	4.7	9.0	7.0	5.0	9.0	7.7
16.	2,4-d	0.35	8002LP	110	140	5.0	6.3	9	5.7	6.3	9	2.7	5.0	4.3	2.7	6.7	4.0
17.	Bromox/MCPA	0.56	8002LP	110	140	8.7	8.7	9	7.7	8.7	9	8.7	9.0	7.7	8.3	9.0	8.3
18.	DPX4189	0.02	8002LP	110	140	8.7	8.7	9	8.7	9.0	9	5.7	9.0	8.3	6.0	8.7	7.3
19.	Check	-	-	-	-	-	-	9	-	-	9	0	0	0	0	0	0

Table 3: The effect of nozzle type, herbicide rate, and water volume on the efficacy of paraquat and glyphosate in 1981

Treat No.	Herbicide	Rate (kg/ha)	Nozzle Type	Volume (l/ha)	Pres. (kpa)	Weed Control Rating (Score 0-9) July 7 Dandelion	July 7 N-leaf H-beard	July 7 Overall	July 27 Dandelion	July 27 N-leaf H-beard	July 27 Overall
1.	glyphosate	0.45	8002	110	280	7.5	9.0	7.5	7.0	6.0	7.0
2.	glypho. + ag	0.45	8002	110	280	7.5	9.0	8.0	7.0	7.0	7.0
3.	paraquat	0.54	8002	110	280	5.5	8.5	7.0	4.5	6.0	5.5
4.	glyphosate	0.45	8001	55	280	8.5	9.0	8.0	7.5	4.8	7.5
5.	glypho. + ag	0.45	8001	55	280	9.0	9.0	8.5	8.0	8.5	8.0
6.	paraquat	0.54	8001	55	280	3.0	6.0	4.5	4.5	5.0	3.2
7.	glyphosate	0.23	8001	55	280	7.5	4.4	6.5	6.5	8.0	3.9
8.	glypho. + ag	0.23	8001	55	280	8.0	9.0	8.0	8.0	7.5	7.5
9.	paraquat	0.27	8001	55	280	5.0	6.0	4.5	4.5	6.0	5.5
10.	glyphosate	0.45	CDA	45	140	8.5	9.0	8.5	8.0	7.5	7.5
11.	glypho + ag	0.45	CDA	45	140	7.0	7.5	6.0	8.0	7.0	7.5
12.	paraquat	0.54	CDA	45	140	4.0	5.0	4.5	5.0	5.0	5.0
13.	glyphosate	0.23	CDA	45	140	5.5	6.5	5.5	6.0	7.0	7.0
14.	glypho. + ag	0.23	CDA	45	140	7.0	8.0	6.0	8.0	7.0	7.5
15.	paraquat	0.27	CDA	45	140	1.0	2.5	1.0	2.5	3.0	3.0
16.	glyphosate	0.45	8002LP	110	140	7.0	8.5	7.5	6.5	8.5	7.5
17.	glypho. + ag	0.45	8002LP	110	140	9.0	9.0	8.5	8.0	8.5	8.0
18.	paraquat	0.54	8002LP	110	140	5.0	7.0	4.5	6.0	5.5	5.5
19.	check	-	-	-	-	0	0	0	0	0	0

+ ag = agsurf added at .5% by volume.

Table 4: The effect of nozzle type, herbicide rate, and water volume on the efficacy of paraquat and glyphosate in 1982

Treat No.	Herbicide	Rate (kg/ha)	Nozzle Type	Volume (l/ha)	Pres. (kpa)	Weed Control Rating (Score 0-9) June 24 Flix Weed	June 24 Dandelion	June 24 Wild Oats	June 24 Green Foxtail	July 8 Flix Weed	July 8 Dandelion	July 8 Wild Oats	July 8 Green Foxtail
1.	glyphosate	0.45	8002	110	280	5.3	4.0	7.3	6.7	6.7	5.7	8.7	8.0
2.	paraquat	0.54	8002	110	280	7.3	4.7	7.7	8.0	6.7	3.3	9.0	9.0
3.	glyphosate	0.45	8001	55	280	7.7	3.7	7.7	6.3	7.6	6.3	8.7	6.0
4.	paraquat	0.54	8001	55	280	5.0	2.0	6.0	4.3	4.3	2.3	8.3	5.0
5.	glyphosate	0.23	8001	55	280	7.0	3.0	6.7	6.3	7.0	6.0	7.7	4.0
6.	paraquat	0.27	8001	55	280	6.0	2.7	5.3	5.0	4.3	0.0	7.7	5.0
7.	glyphosate	0.45	CDA	45	140	8.3	7.0	5.7	5.3	8.0	7.3	7.3	5.3
8.	paraquat	0.54	CDA	45	140	5.3	3.0	5.7	5.7	4.7	2.0	8.3	5.3
9.	glyphosate	0.23	CDA	45	140	5.3	1.3	5.7	6.3	3.7	0.3	5.7	5.7
10.	paraquat	0.27	CDA	45	140	7.7	4.3	6.7	5.3	5.7	4.7	7.3	3.3
11.	glyphosate	0.45	8002LP	110	140	7.3	3.3	6.7	6.0	6.7	5.0	7.7	4.7
12.	paraquat	0.54	8002LP	110	140	7.3	3.3	6.3	6.0	7.3	3.0	8.7	7.7
13.	check	-	-		-	0	0	0	0	0	0	0	0
14.	check	-	-		-	0	0	0	0	0	0	0	0

glyphosate used with agsurf at .5% v/v.

Table 5: Initial pattern evaluation of CDA units 1 and 2

Saskatchewan Wheat Pool -- Micromax Units No. 2 and 1

Flow Rate - 989.943 ml/min Speed - 2045.2011 rpm Volt - 13.5 v
PR - 145 KPA Height - 280 mm Spacing - 1000 mm (File: SWP01)
N - 279.0 Mean - 32.68 C. of V. - 40.15

Saskatchewan Wheat Pool -- Micromax Units No. 2 and 1

Flow Rate - 973.877 ml/min Speed - 2099.2086 rpm Volt - 13.5 v
PR - 145 KPA Height - 280 mm Spacing - 1800 mm (File: SWP02)
N - 279.0 Mean - 32.06 C. of V. - 42.55

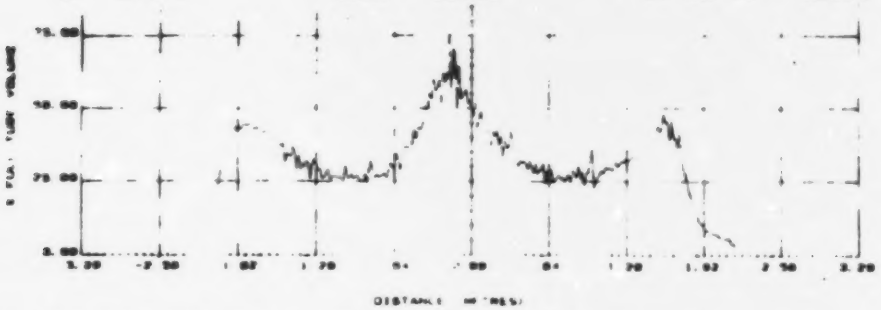


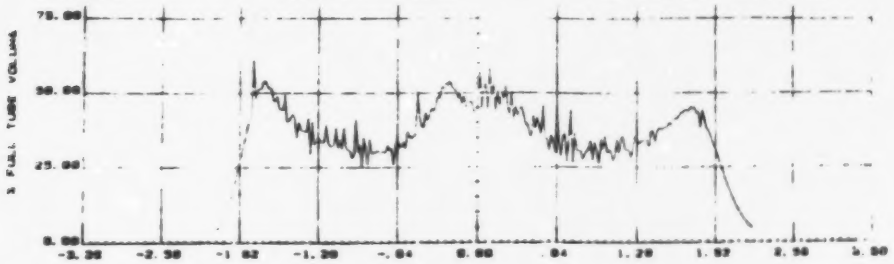
Table 6: Pattern evaluation after 12.5 hours of operation

Saskatchewan Wheat Pool -- Micromax Units No. 2 and 1

Flow Rate - 885.911 ml/min Speed - 1980.1900 rpm Volt - 13.5 v
PR - 145 KPA Height - 280 mm Spacing - 1800 mm (File: SWP03)
N - 272.0 Mean - 35.98 C. of V. - 31.07

Saskatchewan Wheat Pool -- Micromax Units No. 2 and 1

Flow Rate - 884.954 ml/min Speed - 1843.1770 rpm Volt - 13.5 v
PR - 145 KPA Height - 280 mm spacing - 1800 mm (File: SWP04)
N-258.0 Mean - 31.25 C. of V. - 33.19



weed control to the 8001 nozzles.

Recommended herbicide rates are designed to provide excellent weed control over a wide range of environmental conditions and weed and crop situations. Our results indicated that reducing the recommended herbicide rate generally decreased the consistency of control with a given herbicide. In no case did the CDA provide superior herbicide efficacy than the TeeJet 8001 nozzle when reduced herbicide rates were used.

SOCIO-ECONOMICS

THE ECONOMICS ORGANIZATION OF RURAL HOUSEHOLDS IN SASKATCHEWAN

W.H. Furtan and J.S. Clark

ABSTRACT

One of the major centres of economic activity is within the household. The allocation of time, expenditures and savings are all made within the household. Also decisions as to the number and quality of children are choices that eminate from the household. The choices made within the household also have a direct bearing on the size and type of farm, primarily through the labour market.

The purpose of this research project was to build an economic model of household decisions. A sample of 630 farms taken from the Western Grain Stabilization list were personally interviewed. The data was placed on the computer and analyzed using the new household economics.

The research found farms to be increasing in size and little in the future to stop further growth. The income level of farm households was also explained using such variables as education, inheritance and market luck. Finally, family size and time allocation was explained using the new household economics.

BACKGROUND AND OBJECTIVES

The economic structure of Saskatchewan agriculture has gone from one of farm homesteads to a highly capital intensive industry. This has taken place in the short space of fifty years. Perhaps more profound changes than those of increased farm size are changes in the lifestyle of individual farm families. Families have fewer children, parents are more educated, more off-farm work is undertaken by both husband and wife and the families are enjoying more leisure. All of this has occurred because of changing price ratio's and increased levels of household income.

From casual observation of Saskatchewan agriculture, it appears that certain parts of the province are on different growth paths. Farms in the west central part of the province appear different than those in the east central part. Two reasons may give rise to this observation; (i) the technology function may be different in the two areas; (ii) the only difference is in size and some other reason such as when the area was developed explains the difference in size. Farm size can be a confusing and misleading concept unless it is adequately understood and accounted for by the observer.

A second observation is that income is highly concentrated in the farm sector. One observes that some farm families have high income while others are near or below the poverty levels. Much of the government policy that is put in place is aimed a reducing the income differences

between individuals or families in society. However, before adequate policy can be developed, one must understand what gives rise to the differences in income levels.

More specifically the objectives of the research project were:

(i) develop a data base on rural farm households in Saskatchewan;
(ii) determine if there is scale to be acheived in agricultural production;
(iii) determine the factors that effect the economic decisions made in households (family size, education, etc.); and
(iv) determine what economic factors effect the distribution of income between individuals and households.

EXPERIMENTAL METHOD

The theoretical framework used in this analysis was based upon a profit maximizing function for farm firms. For the component on rural households the theoretical model was the new household economics. This theoretical model provided the basic structure for which the data was collected.

The data requirement was exceedingly large and detailed. For the most part the required data was not available from public sources such as Statistics Canada. This meant a primary collection of data was required which was undertaken in crop districts five and seven in the province of Saskatchewan.

A list of farmers in the two crop districts was secured from the Western Grain Stabilization office in Winnipeg. This list included most farmers in the two crop districts from which a sample of six hundred and thirty farms were selected at random. The farmers selected were contacted by letter indicating the purpose of the survey and the approximate dates that they would be interviewed. Each farm family was personally interviewed between May and August of 1981. Once the data was collected, it was entered onto the computer and the appropriate analysis done.

RESULTS AND DISCUSSION

The data collected revealed some major differences between the two crop districts (Table 1). Clearly farms in crop district five are larger and more capital intensive, however, net revenue per acre land value is the same between the two districts.

The profit equation used to explain the difference in technology between the regions was specified as:

$$\ln \quad = \ln A^E + dD^W + a \ln N + b_1 \ln Ed + b_2 \ln K + u_i,$$

Table 1.A: Data Mnemonics

Mnemonic	Interpretation
TOTLAB	(weeks summer and weeks winter) - husband, wife, children, paid labour, unpaid labour;
NUMCHIL	average # of children over all families on farm;
EDHUS	average education of husband over all families; (years)
EDWIFE	average education of wife over all families; (years)
THE	average total household expenses over all families; (dollars)
OPLAND	total operated land; (acres)
OWNLAND	total owned land; (acres)
GFI	gross farm income; (dollars)
LANDV	land and buildings value; (dollars)
MACHV	machinery value; (dollars)
LIVEV	livestock value (breed herd); (dollars)
PDHIRE	hired labour (weeks winter and weeks summer);
THEDP	(average total household exp.)/(# dep. children and parents/families); (dollars)
FARMEXP	total farm expenditures (excluding "others"); (dollars)
AGE	(total age of husband + wife for all families)/# husband and wives; (years)
GFIDDEP	GFI + rented land income + dividends income + custom work income + total yearly family wage (dollars) / (# dep. children + parents)
GFIMDDEP	(GFI + rented land income + dividends income + custom work income + total yearly family wage - farm expenses)/# of parents + # of dep. children); (dollars)
WEALTH	Value of inheritance, gifts and other support in 1980 dollars

Table 1.B

Variable	Full Sample		Crop District 5		Crop District 7	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
TOTLAB*	87.217	62.259	89.83	65.3	84.4	58.7
NUMCHIL	2.712	2.075	2.66	2.1	2.7	2.0
EDHUS*	10.06	2.64	9.57	2.64	10.86	2.70
EDWIFE*	9.51	4.26	10.53	2.60	11.75	2.21
THE	55030	32264	44830	27795	65817	33187
OPLAND*	1062	806.3	842	650.4	1293.8	887.6
OWNLAND*	831.87	665.12	679.7	499.6	992	772.8
GFI*	59003	73274	45257	74017	73541	69714
LANDV*	529380	566870	328550	319490	741770	682900
MACHV*	93839	93381	78619	80052	109940	103400
LIVEV	13932	38421	13033	27914	14882	47082
PDHIRE	3.2282	9.5013	2.72	8.6660	3.75	10.3
THEDP*	20857	15439	17376	13208	24539	16745
FARMEXP	30608	474412	25475	56738	36037	34220
AGE	44	12	45.5	12.873	43.2	12.40
GFIDDEP	23230	29425	19344	34899	237340	21530
GFIMDDEP*	12868	12750	10336	11794	15546	13190
WEALTH*			149000	1744764	161909	1551234
GFI/LANDV			.15768	.20306	.132	.257
MACHV/LANDV*			.28588	.44728	.203	.267
TOTLAB/LANDV*			.00049	.00075	.00019	.00027
MACHV/TOTLAB*			1282	1891.8	1787	1913

* The difference between the mean value of crop district five and seven are significant at the 95 percent level.

where π = gross farm income less variable costs;
N = number of weeks of family labour plus other unpaid labour;
ED = the number of years of school completed by the husband and wife;
K = fixed capital (.07 land value + .10 machinery value + .13 value of breed herd);
U_i = an error term with the usual properties.

The results of the estimations are given in Table 2. The technical coefficient for crop district seven is significantly larger than for crop district five. This implies that farms are more productive in crop district seven. The statistical fit on the equations and fixed factors is significant as indicated by the R^2 and t-statistics. The profit function was also tested using a translog form of the equation.

In the second set of regressions (Equation 3 and 4), the parameters in the profit function were restricted to sum to unity. The hypothesis of constant returns to scale was tested using the chi-square test which is reported in Table 3. The hypothesis of constant returns to scale is rejected at the 5 percent level.

The quantity of land rented is significant in both crop districts five and seven of Saskatchewan. A test was developed to determine if the proportion of rented land had any impact on the technical efficiency of the farm. Suppose R is the proportion of land leased and that the technical coefficient A^i, i (E, W), is related to R as

$$A^i_{\#} = B^i_{\#} fR$$

where $B^i_{\#}$ is the technical constant in the profit function for each crop district after the correction for land tenure. In this case the estimating equation becomes

$$\ln \pi = \ln B^E_{\#} + fR + dD^W + a \ln N + b_1 \ln Ed + b_2 \ln K,$$

where R = (quantity of rented land/quantity of land farmed) 100, and

$$d = \ln (D^W_{\#}/D^E_{\#}).$$

The results of the estimation are shown as equation (5) in Table 2. There is a statistical connection between land that is rented and land that is owned. Perhaps a person who rents land over grazes it if it is pasture, or in the case of cash rent, pays more than the land is worth.

A second area of investigation was the distribution of farm income amongst farm families. The distribution of income for the sample of farms studied is shown in Table 4. The income is skewed toward the lower levels with a few farm families receiving the majority of the income (i.e. 70.53 percent of the farms receive 38.14 of Farm Well Being).

The economic analysis of household decisions supports the notion that as the eduction of women increases, the number of children decreases. Also as family income rises the number of children declines. Finally, the labour allocation between the household, the farm and off-farm work is extremely important in determining the structure of agriculture.

IMPACT

The impact of this research project is in its explanation of basic economic decisions of rural households. The study does not make specific policy recommendations.

The most important finding is that labour allocation within the household is one of the key decisions made by families. The impact of this finding is that any policy aimed at maintaining family farms must take into account labour decisions. A second finding is that growth in farm size is likely to continue in the province. The impact of this decision is that governments (particularly municpal governments) must plan for fewer farm people in making decisions regarding schools, hospitals, etc.

Perhaps the most important impact this study will have is the availability of a data base on rural Saskatchewan. The data collected is unique in many ways and is likely to be heavily used by other scientists in the future.

Table 2.0: Regression Results for Farm Size

Variable / Profit Function	OLS Restricted	OLS	OLS Restricted	OLS Restricted	OLS
Equation No.	(1)	(2)	(3)	(4)	(5)
ln A	1.07657	1.2528	1.6127	1.6393	0.8943
	(3.3672)*	(3.9638)	(7.2412)	(7.511)	(2.625)
t	---	0.23885	---	0.25054	0.05208
	---	(4.7771)	---	(5.0516)	(4.367)
s	0.07241	0.09782	0.5682	0.08376	0.10008
	(2.1349)	(2.9007)	(1.5481)	(2.5590)	(2.8019)
b^1	0.301945	0.27576	0.17657	0.18611	0.36050
	(4.67389)	(4.2992)	(24.896)	(5.1661)	(5.2149)
b^2	0.77240	0.73187	0.77274	0.73012	0.74641
	(24.976)	(23.217)	(4.8081)	(23.13)	(21.365)
f					-0.002541
					(-2.809)
R^2	0.63	0.64	0.62	0.64	0.65

* t-statistics are given in parentheses.

Table 3: Tests of Hypotheses

Hypothesis	Chi-Squared Test		Equation Number
	Computed Value	Critical Value at 5 Percent	
$a + b_1 + b_2 = 1.0$	5.84	3.84	4
$f = 0$	7.891	3.84	5
$f = 0$			
$d = 0$	17.621	3.84	3

Table 4: Concentration of Farm Well-Being

Income Category	Cumulative Farm Well-Being	Percentage of Farms
<5,000	0.25	3.13
5-9,999	1.44	9.39
9-14,999	5.00	20.99
9-19,999	10.26	33.14
9-24,999	16.90	44.93
9-29,999	21.88	52.30
9-34,999	29.08	61.32
9-39,999	33.68	66.29
9-44,999	38.14	70.53
9-49,999	42.48	74.21
9-60,000	54.43	83.05
0-70,000	61.78	87.66
0-80,000	69.23	91.71
0-90,000	73.91	93.92
0-100,000	77.81	95.58
100,000+	100.	100.

MISCELLANEOUS

STRAIN IMPROVEMENT APPROACHES IN ZYMOMONAS MOBILIS, I. STUDIES ON CONJUGATION WITH ESCHERICHIA COLI

George G. Khachatourians and Ka-Yin Leung

ABSTRACT

The bacterium Z. mobilis can yield 7 - 12% ethanol only from glucose, sucrsose and fructose. In order to broaden the fermentative substrate range, alcohol tolerance strain improvements are being explored. Our strategies for such strain improvements include bacterial conjugation and selection. The frequency of the conjugal transfer of F- and R- plasmids into Z. mobilis is very low and in the order of 10^{-7} to 10^{-8}. The reasons for the low frequency of mating have been researched and shown to be due to the presence of ethanol and other metabolites normally found in growing cultures of Z. mobilis. Overcoming these causes of interference with mating efficiency will greatly facilitate strain construction by in vivo genetic crosses.

BACKGROUND AND OBJECTIVES

The species of Zymomonas, which is used in the tropics to produce palm wines (Swings & De Ley, 1977), has been reported to offer potential significant cost reduction for ethanol production (Roger et al, 1979). This bacteria, which uses the Entner-Doudoroff pathway for glucose metabolism, can produce approximately 2.0 moles ethanol per mole of glucose fermented (Swings & De Ley, 1977). However, Zymomonas can only ferment glucose and fructose; utilization of sucrose is strain dependent. In order to be industrially useful, genetic manipulation should be developed to broaden the carbohydrate spectrum of Zymomonas.

In North America, large quantities of dairy whey is produced each year by the cheese industry. Instead of disposing all this lactose containing waste, it would be desirable to construct a lactose utilizing Zymomonas strain to directly convert dairy whey lactose into alcohol.

The objective of this research is to use conjugation technique transfer F' lac and other plasmids from E. coli to Zymomonas. If Zymomonas can accept and maintain the F' lac or other plasmids, direct fermentation of dairy whey lactose into alcohol would then be practical.

EXPERIMENTAL METHOD

Several donor strains of E. coli, harboring conjugative plasmids F' lac$^+$ (GK71 and GK75), R tet sul^r (GK221 and GK742-751), and F'lac$^+$ R tet^r sul^r (GK752-754) were used to conjugate into E. coli recipients GK402, 403 and Z. mobilis GK650 and 651.
Mating experiments were performed in liquid growth medium and recombinant progeny were detected on selective plates. For the F'lac+ plasmids the

selection consisted of the ability to grow and ferment lactose and for the R-plasmid, growth on plates containing anibiotics tetracycline and sulfanilamide. Bacterial growth and media are described in Leung (1982).

The mating frequency was calculated from the following equation:

$$\text{Mating Frequeny} = \frac{\text{Number of Transconjugants (CFU/ml)}}{\text{Number of Donor cells (CFU/ml)}}$$

RESULTS AND DISCUSSION

New Donor Bacteria

Although the E. coli donor strains GK71 and GK75 contain distinct genotypes which would permit counter selection, E. coli strain GK403 was used to construct alternative donor strains for the E. coli and Z. mobilis mating experiment. The advantage of using GK403 was due to its minicell producing character (min A, B genotype) which would be an additional morphological marker allowing phenotypic separation of the two bacteria. A donor strain with conjugative R plasmid (R348N) from E. coli strain GK221 was first constructed in strain GK403. The transconjugational frequency was 3.8×10^{-5} per each donor cell. Ten transconjugants were obtained from this mating (GK742-GK751). Afterwards, the F'lac plasmid from strain GK71 was transferred to strain GK742 with a frequency of 3.9×10^{-6}. The transconjugants: GK752, GK753 and GK754 were similar to E. coli strain GK403 except in harbouring R and F'lac^+ plasmids.

One criterion used to test the presence and stability of plasmids in bacteria is the susceptibility of such plasmid DNA to be lost ("cured") either spontaneously or with chemicals such as acridine orange. All donor bacteria were tested for spontaneous or acridine induced loss of plasmid coded characters (lac^+ or tet^r). At least 200 colonies were scored for each test strain. Chromosome encoded characters were also checked in these tests. For donor strains E. coli GK71 and 75 spontaneous curing rate was 0% and 2.1%, indicating fairly good stability of the plasmids. In the presence of acridine orange the curing rate was 96.2% and 86.4% for the same two strains. The R and F plasmid harbouring strains GK752 and GK753 showed 21.7% and 16.8% spontaneous - and 40.2% and 36% acridine - induced curing of the F'lac^+ plasmid. Because of higher percentage of spontaneous loss of F'lac^+ in the latter two strains we suspect that they are somewhat unstable. This can be explained by the incompatibility between R(348N) and F'lac^+ plasmids, both present in these bacteria. Thus, while double plasmid bearing strains (GK752 and 753) are more versatile, they are not as stable donors as the single plasmid, F'lac^+, harbouring strains (GK71 and 75).

Selection Schemes in Conjugal Crosses

The phenotypic character of bacteria used in the conjugal crosses were established previously (Khachatourians and Leung, 1982). There were two conjugal crosses. The first was to use wild type E. coli lac^+ strains (GK71, GK75 or GK98) and Z. mobilis lac^- strains (GK650, GK651, GK656, or GK657) as donor and recipient strains respectively. The characters, lactose fermentation and streptomycin resistance were the primary selection scheme. The second conjugal crosses contained E. coli GK752 and Z. mobilis strain GK705 as alternative donor and recipient strains. In this case, cellular morphology of the donor, that is minicell production and resistance to tetracycline and chloramphenical, was used as additional selective markers.

Heterogeneric Mating Between E. coli and Z. mobilis Strains

The first mating group was to transfer E. coli lactose utilizing genes from plasmids F'lac^+ (strains GK71, GK75) or the chromosome (GK98) to Z. mobilis strains (GK650, GK651, GK656, or KG657. Liquid mating, semi-solid mating, patch mating and membrane mating were tried. Modified mating techniques such as using 30C mating temperature rather than 37C, 4 hours or overnight (24 hours) mating time rather than 1 hour, anaerobic mating rather than aerobic mating, and addition of mineral salts were attempted. As no lac^+ transconjugants were obtained after several trials of mating, another alternative heterogeneric mating was established by mating E. coli strain GK752, which harbours Z plasmids, F'lac^+ and R(348N) with Z. mobilis strain GK705. The mating method was the same as previous mating, except tetracycline (100 ug/ml), chloramphenicol (50 ug/ml), lactose and cellular morphology were used as selection markers for potential transconjugants. This time, only the R plasmid (R348N) was observed to transfer into Z. mobilis GK705 with a frequency of 1.4×10^{-7}. The transfer of F'lac plasmid was less than 1×10^{-8} (Table 1).

Table 1. Heterogeneric Mating Frequency Between E. coli and Z. mobilis strains

Mating pair						Mating	Stable
Donor	Recipient	Selective markers				Frequency	Transconjugants
GK71 or GK650,GK651							
GK75 or GK656,orGK657		lac^+	str^r			$<1 \times 10^{-8}$	none
GK98							
GK752	GK705	lac^+	cml^r	$minA^-$	$minB^-$	$<1 \times 10^{-8}$	none
GK752	GK705	tet^r	cml^r	$minA^-$	$minB^-$	1.4×10^{-7}	GK755-GK760

Effect of Z. mobilis on Donorability of E. coli

In order to understand the reason behind the low mating frequency, growth kinetics and mating ability of E. coli strains were studied either in the presence or absence of Z. mobilis. In Figure 1A E. coli strain GK71 was incubated statically in pure or mixed culture with Z. mobilis. It was observed that the growth rate of GK71 dropped dramatically when incubated with Z. mobilis GK651. About 2 fold and 3 fold differences in terms of the viable count (CFU/ml) were observed at 1 and 3 hours, respectively. The same effect was also observed from E. coli strains GK402 and GK752 when co-cultured with Z. mobilis strain GK651. No inhibition effect was observed when Z. mobilis strain GK651 was incubated in the presence of E. coli cells or overnight E. coli cell-free filtrate (figure 1B). A parallel effect was also observed when a homogeneric mating between E. coli strains (GK71 and GK402) was established in the presence or absence of Z. mobilis strain GK651. In this case, the number of transconjugants dropped significantly in the presence of Z. mobilis GK651.

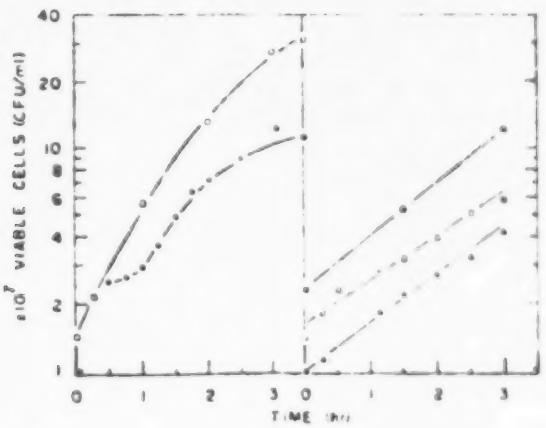


Figure 1. The effect of Z. mobilis (GK651) on the growth of E. coli (GK71).

A. E. coli GK71 was incubated either in pure culture of YGB (O), or with Z. mobilis strain GK651 in mixed culture of YGB ( ).

B. Z. mobilis GK651 was incubated either in pure culture of YGB ( ), or with E. coli strain GK71 in mixed culture of YGB ( ), and with 60% overnight E. coli strain GK71 cell-free filtrate ( ).

Proposed Reasons for Low Donor Ability and Decreased Growth Rate of E. coli in the Presence of Z. mobilis

The growth kinetics of E. coli GK71 was studied under several conditions: GK71 incubated statically at 30C in YGB as control, in YGB plus 1% ethanol (v/v), in YGB plus 90% overnight Z. mobilis GK651 cell-free

filtrate, and in YGB with Z. mobilis GK651 at 1:1 ratio of viable count. The results are summarized in Table 2.

Table 2. The effect of Z. mobilis GK651 on growth rate of E. coli GK71

Treatments	Growth rate of E. coli OD /hr 610	%
None (Control)	0.1260	100.0
1% (v/v) ethanol	0.0900	71.4
90% overnight Z. mobilis filtrate + 10% yeast glucose broth	0.0726	42,4
co-cultures with Z. mobilis	1.1716	13.2

It was observed that the addition of 1% ethanol decreased the growth rate of GK71 to about 30%. The addition of 90% overnight Z. mobilis cell-free filtrate decreased the growth rate of GK71 to about 40%. The addition of log phase Z. mobilis culture decreased the growth rate of GK71 to about 90%. In this experiment, overnight Z. mobilis cell-free filtrate was diluted with YGB (10X) plus sterile distilled water. The dilutions were such that various concentrates of overnight Z. mobilis cell-free filtrate were obtained with YGB at concentration of 1X. Similar growth inhibition effects of overnight Z. mobilis GK651 cell-free filtrate towards E. coli strains were also observed when incubated with GK221, GK403, GK752, and GK753 (Figure 2).

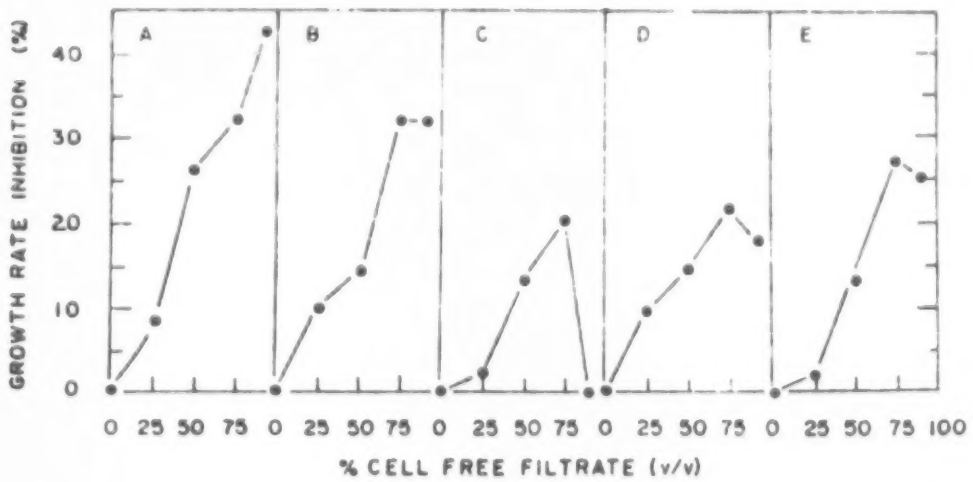


Figure 2. The effect of overnight Z. mobilis (GK651) cell-free filtrate on growth kinetics of E. coli strains: GK71 (A), GK221 (B), GK403 (C), GK752 (D), GK753 (E).

In these experiments, several factors that might decrease the growth rate and donor ability of E. coli in the presence of Z. mobilis were studied in detail. One percent ethanol (v/v) was used to simulate the maximum ethanol concentration that Z. mobilis could produce in YGB. Overnight Z. mobilis cell-free filtrate was used to study the effect of ethanol and other end products Z. mobilis could produce. In addition, Z. mobilis log phase culture was used to study the effect of cell to cell interaction of E. coli. It was observed that cell to cell interaction of Z. mobilis to E. coli had a greater inhibitory effect than ethanol or other end products produced by Z. mobilis (Table 2).

In minimal medium of E. coli (MGA), Z. mobilis GK651 did not grow well. Less than 25% increase in optical density at 610nm of GK651 was found after 6 hours of incubation in MGA broth (Figure 3).

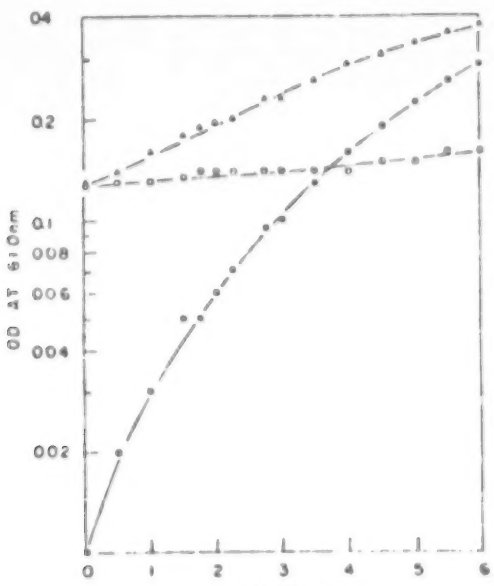


Figure 3. Growth studies of Z. mobilis and E. coli in E. coli minimal medium.
E. coli GK71 was incubated either in pure culture ( ), or with Z. mobilis strain GK651 in mixed culture ( ).
Z. mobilis GK651 was incubated in pure culture ( ).

Microscopic observation revealed the presence of irregular and filamentous cells. When Z. mobilis GK651 was co-cultured with E. coli in MGA broth, the viability of GK71 was found to decrease dramatically in the first 2 hours (Figure 4). After the first 2 hours the growth kinetics of GK71 in mixed culture with KG651 started to accelerate and maintain the same growth pattern as the control (GK71 in pure culture). It was observed that the 2 growth curves paralleled at 5 hour time after the co-culturing.

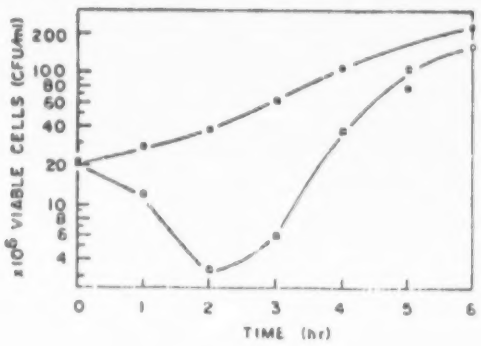


Figure 4. The effect of Z. mobilis (GK651) on the growth of E. coli (GK71) in E. coli minimal medium.
E. coli GK71 was incubated in pure culture ( ), or with Z. mobilis strain GK651 in mixed culture ( ).

Furthermore, it was observed that Z. mobilis GK651 would not decrease the donor ability of E. coli GK71 when co-cultured in MGA broth (Table 3). Therefore, the results suggested that nongrowing Z. mobilis cells would not affect the growth rate and donor ability of E. coli.

Table 3. The effect of Z. mobilis on E. coli mating in minimal medium of 30°C[a]

Mating time	Number of lac^+ str^r transconjugant (CFU/ml)	
(hours)	E. coli mating pair (GK71 x GK403)	E. coli mating pair + Z. mobilis (GK71 x GK403) + GK651
2.0	1.1×10^3	7.8×10^2
3.5	7.5×10^2	8.2×10^2
5.0	7.7×10^2	9.4×10^2

(a) GK71:GK403:GK651 = 6.6×10^7:3.3×10^7:3.2×10^7 (CFU/ml)

A definite problem when E. coli is co-cultured with Z. mobilis was observed. During mating (co-culturing) both the growth rate and donor ability of E. coli was inhibited. On the other hand, the growth of Z. mobilis, the potential recipient of the intergeneric mating during co-culturing, was unaffected. Such phenomena may explain the observation of low mating frequency for F'lac$^+$ and R plasmids between E. coli and Z. mobilis. Alternately , as E. coli and Z. mobilis belong to different genera, the formation of mating pairs or transferring of plasmids may be a problem.

Additionally, the resident plasmids found in Z. mobilis (see section II of this report) may interfere with the conjugally transferred plasmids. Incompatability between these and incoming E. coli plasmids may be a hindrance in the expressions and stabilities of F'lac and R plasmids, and result in low frequency of stable transconjugant recovery. The inhibitory effect of Z. mobilis cells towards E. coli was identified as the major problem that leads to low mating frequency. We have already found that non-growing Z. mobilis cells will not affect the growth rate and mating ability of E. coli. This phenomena may give us a handle to plan the future mating experiment.

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STRAIN IMPROVEMENT APPROACHES IN ZYMOMONAS MOBILIS, II. STUDIES ON ENDOGENOUS PLASMID DNA

George G. Khachatourians and Tom L. Haffie

ABSTRACT

The presence of endogenous plasmid DNA in Z. mobilis was examined. Z. mobilis strains GK650 and 651 were lysed and their cellular DNA contents were purified. These DNA were analysed by dye-buoyant density gradient

ultracentrifugation. Two distinct bands of DNA were recovered from such gradients; that belonging to chromosomal DNA and a smaller satellite band of plasmid DNA. Plasmid DNA were dialyzed and separated electrophoretically on agarose gels. Two plasmids were found in strain GK651 and four plasmids in GK650. We are investigating these plasmids for their biological properties and utility as vectors for in vitro genetic engineering and improvement of the carbohydrate utilizing ability of Z. mobilis.

BACKGROUND AND OBJECTIVES

Plasmids are extrachromosomal DNA molecules which exist as autonomously replicating genetic material within the cytoplasm of bacteria, yeasts and fungi. Plasmids code for many phenotypes for example, mating, pathogenicity and virulence towards animals and man, resistance towards antibiotics and metals, antibiotic production, and bacteriocin production. One of the industrially useful utilizable aspects of plasmids has been "genetic engineering" of multiple plasmids which can degrade crude oil, in Bunker C type oil or oil spills. Microbial plasmids are widespread in nature and it is not unusual to find plasmids in many bacteria. The difficulty however, is in isolating plasmids, correctly identifying their molecular character and associating phenotypes with plasmid genes. Once such an identification process is complete, researchers can, through the methods of gene splicing and recombination in vitro, create plasmid chimeras with "new" phenotypes. The insertion of such chimeric plasmids into the original cell then generates "tailor-made" organisms.

The objective of this product is to use the techniques of molecular biology to isolate and identify the physical characters of plasmid DNA from Z. mobilis. Once such plasmids are available and their molecular charactes have been identified, their in vitro genetic engineering can be envisaged.

EXPERIMENTAL METHOD

Z. mobilis strains GK650 and GK651 were used for isolation and characterization of plasmid DNA. In addition to the use of commercially purchased purified plasmid and bacteriophage DNA markers, multiple plasmid harboring strains E. coli GK50 (8 plasmids) and S. typhimurium strain GK410 (2 plasmids) were employed as molecular weight standards for sizing of Z. mobilis plasmids. Late log-phase cells of these bacteria were subjected to lysozyme/EDTA treatment followed by lysis using a detergent Brij-deoxycholate mixture. Significantly improved lysis was accomplished through this, over other methods reported in the literature. Lysates were subjected to Ethidium Bromide - Cesium Chloride (EBr-CsCl) buoyant density ultracentrifugation. The plasmid DNA was resolved from chromosomal DNA by viewing gradients under ultraviolet light. Purified plasmid DNA from EBr-CsCl gradients or from total culture lysates were further analysed by agarose gel electophoresis. Our methods were scaled

down to allow analyses of DNA from a few colonies or 3 mls of an overnight culture.

RESULTS AND DISCUSSION

Physical Characterization

It is obvious that this study is dependent on a reliable procedure for extracting intact Zymomonas plasmids. The literature is of little assistance since Skotnicki et al (1980, 1982) have not published a protocol in sufficient detail to be reproduced and the Dally et al., (1982) method is time consuming and restricted to large volumes. We have found Zymomonas to be generally amenable to lysozyme/EDTA/detergent lysis procedures and have, with some modifications, used them to extract plasmids both preparatively from large (300-500 ml) cultures and also from smaller (3 ml) volumes for screening. To date a total of 35 different plasmid preparations have been made and analysed by agarose gel electrophoresis and EBr-CsCl ultracentrifugation.

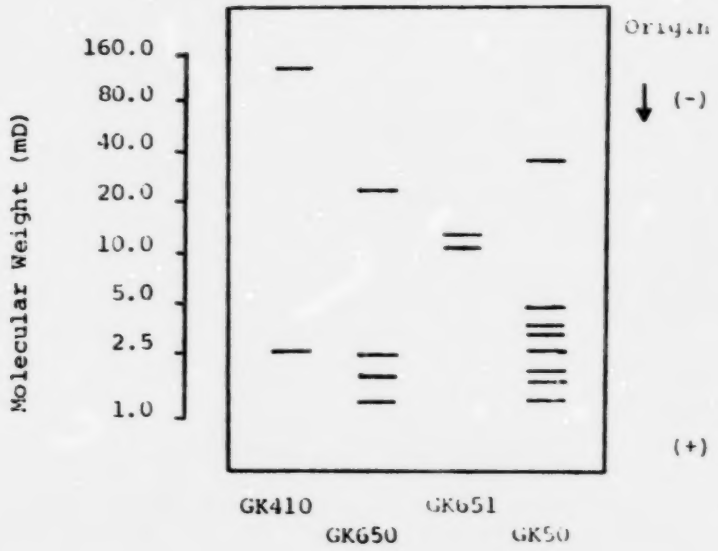

Figure 1. Plasmid spectrum for Z. mobilis (GK650 and GK651) plasmid marker strains E. coli GK50 and S. typhimurium GK410.

The plasmid spectrum has been confidently established for GK650 and GK651 (Fig 1). Our strain of ATCC 10988 (GK650) has four covalently closed circular (CCC) DNA plasmids. Three smaller species in the one to four kilobase pair (Kbp) range (pTH 100-300) and one large plasmid of about twenty Kbp (pTH 400) can be routinely isolated. The two smallest plasmids may be those described by Dally et al, (1982) as mentioned above.

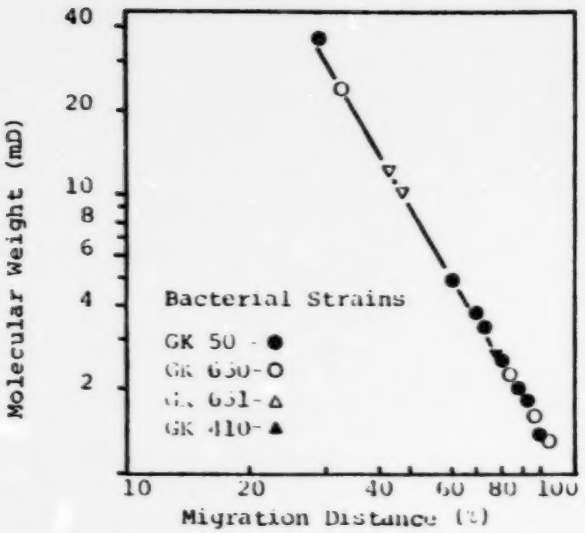

Figure 2. Molecular weight determination of plasmids in Z. mobilis using marker plasmids as standards.

The larger two have not been reported in the literature. Our GK651 strain also contained plasmids not found previously. The large plasmid reported to be in all Zymomonas strains by Dally et al,(1982) was not present in any of our strains tested. The variability in the reported plasmid spectra from various researchers may have resulted from prolonged laboratory culture with little or no concern for maintenance of plasmid containing strains. This situation will hopefully be improved as the importance of Zymomonas plasmids becomes more apparent.

Any of the smaller plasmids found in Zymomonas are potential building blocks for construction of a plasmid vector. For this reason, further research in the short term at least will focus on restriction endonuclease mapping and accurate sizing of these species. Restriction endounuclease maps will have two main roles in the future. First, enzymes which generate five or so fragments provide a "fingerprint" which can be used to identify plasmids isolated from different strains. Second, they will be essential for localization of plasmid borne genes and replication functions as well as possible sites for insertion of passenger DNA in a plasmid vector.

Biological Characterization

As mentioned previously, no phenotypic trait has yet been ascribed to a Zymomonas plasmid. Unsuccessful attempts were made by Skotnicki et al, (1982) to link sucrose metabolism and/or extracellular polysaccharide (levan) production to a plasmid. Our own preliminary ethidium bromide and elevated temperature curing experiments also suggest that these characteristics are not plasmid coded.

Zymomonas reportedly has an inhibitory effect on a number of bacteria and fungi. Cultures have been used therapeutically for topical and vaginal infections by Trichomonas, Candida, E. coli, Neisseria and Streptococcus. We have some results from cross-streak plates which indicate that Erwinia and Salmonella are also inhibited. We intend to screen other microorganisms such as Lactobacillus, Leuconostoc, Micrococcus and Saccharomyces spp. with the hope that Zymomonas has particular antagonism against those species naturally present in the same habitat.

We are interested in the possibility that this ability to inhibit other microorganisms is plasmid mediated. Bacteriocins of various types are known to be commonly coded extrachromosomally in other bacteria and the potential for a similar system in Zymomonas is worth purusing.

The intuitive first choice for a probable plasmid function is antibiotic resistance. The published antibiotic resistance spectrum has been expanded and we have found general resistance to kanamycin, streptomycin, naladixic acid and the beta lactams. Zymomonas is characteristically sensitive to tetracycline, chloramphenicol and sulfa drugs such as sulfamethoxazole.

Plasmid coded resistance to the penicillins is normally conferred by a lactamase which inactivates tha antibiotic. An iodometric test for lactamase was run on our Zymomonas parent strain as well as a number of potentially cured clones. None of the Zymomonas gave a typical positive response as shown by an ampicillin resistant E. coli control culture. These results suggest that either Zymomonas does not employ a lactam ring cleavage mechanism for penicillin inactivation or some other physical alteration of the target enzyme or permeability confers high level resistance.

In summary, the plasmid complment of Zymomonas GK650 has been established and differs from literature reports. The plasmids have been sized and restriction analysis is underway.

Basic research will be necessary if we are to expand the seriously restricted natural substrate range of Zymomonas. No known strain can ferment any substrate other than glucose, fructose or sucrose. The utility of Zymomonas would be increased dramatically if a strain could be found or constructed with the ability to use any common waste carbohydrate such as maltose, lactose, starch or various cellulosics.

Construction of improved strains is hampered by a general lack of knowledge and expertise in the area of Zymomonas genetics. Literature reports of conjugation are few and conflicting, the spectrum of indigenous plasmid DNA has yet to be established with certainty and known plasmids remain cryptic.

This initial work has taken place with plasmids foreign to Zymomonas without much regard for the already present plasmid complement. Plasmid incompatabilities may have been responsible for the unsuccessful transformation attempt and for the variable conjugation frequencies (see Section I of the report). It is the aim of this research to characterize any or all of the indigenous Zymomonas plasmids functionally (phenotypic markers) and physically (size, distribution, and restriction endonuclease sites). The ultimate goal is an increased awareness of Zymomonas genetics at least and the construction of a lac^+ plasmid vector at best.

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SANITIZER RESIDUES IN MILK AND MILK PRODUCTS IN SASKATCHEWAN

E.S. Humbert and G. Blankenagel

ABSTRACT

To determine the importance of milk as a possible major contributor to the dietary intake of iodine, 359 fluid and industrial farm bulk tank milk samples were examined for iodine levels. The average iodine value for all producers was found to be 0.929 ppm with fluid milks having a higher concentration (0.990 ppm) than industrial milks (0.677 ppm).

Results showed individual producers' milk ranging from <0.1 to >5.0 ppm iodine with 20% of the milk samples exceeding 1.0 ppm. Of the 41 producers which were selected for a further nine-month study, semi-monthly analyses indicated little variations in concentration, with milks of low initial iodine values generally remaining low and those with high values usually remaining high. Farm inspections suggest that feeds, in particular those supplemented with iodine, are primarily responsible for the increased iodine levels while farm iodine compounds commonly used in normal milking operations are believed to be less important. The use of iodine-containing teat dips and udder washes with selected cows of the University of Saskatchewan herd did not contribute to any noticeable increase in milk iodine levels. Iodine contents of cottage cheese were influenced by the use of iodine treated wash waters with a direct correlation between levels of iodine in the wash water and that in cottage cheese curd. Results of this study suggest that those farmers producing milk containing abnormally high iodine values be reexamined and steps taken to reduce these values to more acceptable concentrations.

BACKGROUND AND OBJECTIVES

One of the concerns of health agencies is the increased level of iodine currently found in some milk supplies. Since iodine-containing sanitizing compounds have been implicated as causative agents, it was decided to concentrate our efforts in this study to measure existing levels in milk and to determine whether these compounds are contributing factors.

The change from an iodine deficient diet to a concern for possible excessive intake for some individuals has been traced to the food supply. Dairy products have been suggested as major contributors, since they accounted for 42% of the dietary iodine in adults, excluding dietary salt, in 1974 with the percentage today being higher and continuing to increase (Bruhn, 1981). Studies conducted to date indicate that various types of feeds and iodine-containing agents used on the farm are responsible for the increased levels found in milk. Disagreement as to which is the most important is apparent, for Dunsmore and Wheeler (1977) emphasized the role of iodine compounds on the farm as major contributing factors. However, others (Heinkev et al., 1981, and Cantor and Most, 1976) suggested that feed is more important and is primarily responsible for these higher-than-normal levels. Since no information appears to be available in Western Canada or indeed all of Canada, this project was undertaken with the objective of (1) measuring iodine levels of raw milk in the Saskatoon milk shed, (2) determining the possible sources of high iodine levels in milk, in particular the importance of feed and farm iodine compounds as contributing factors, and (3) determining the influence of iodine water treatments on iodine levels of cottage cheese.

EXPERIMENTAL METHOD

The initial step in this study was to determine the levels of iodine currently found in the raw milk supply for the city of Saskatoon. Accordingly, 8 oz. samples of milk were collected from each of 359 farm bulk tanks in the Saskatoon area by bulk truck drivers during a one-month period of May-June 1982 and delivered to the laboratory for analysis. This number represented all of the fluid and industrial milk producers in the Saskatoon milk shed. From these data, 41 milk producers were selected for future study representing raw milks with iodine contents ranging from high (>5 ppm) to low (<0.2 ppm) levels. These samples were collected twice monthly by a Dairy Producers Co-op field man commencing July 1982 and continuing until March 1983. The purpose of this phase of the investigation was to determine possible seasonal changes and normal variations which might occur during that period of time. When possible, a Provincial Department of Agriculture inspector visited these farms to observe milking practices and in particular to determine possible use of iodine-containing compounds and types of feeds being utilized.

Information on the effect of an iodine-containing udder wash[1] and a teat dip[2] on iodine levels in milk was obtained using the University of Saskatchewan herd. In the first of two trials, seven cows were randomly selected and 8 oz. samples of the evening milking were collected daily. The trial was divided into three ten-day segments consisting of the pretreatment, treatment, and post treatment periods. The pretreatment period was designed to record normal levels of iodine for each cow without the use of iodine compounds. The ten-day treatment period was started by the introduction of a commercial iodine-containing udderwash and a teat dip used according to the manufacturer's directions. The final post treatment period was included to measure possible after effects of this treatment. The cows were fed on a free choice group basis to meet the 1978 United States National Research Council nutrient requirements. The second trial was similar to the first with the exception that the cows were housed in single stalls and each cow was fed individually according to the above nutrient requirements. Further, a longer time period elapsed before milking after the animals were fed the mineral supplement on a free choice basis.

Iodine determinations of commercially prepared cottage cheese were accomplished by taking 8 oz. samples of curd and whey directly from vats during the manufacturing process at a local dairy plant. Cottage cheese produced under laboratory conditions consisted of placing 4 small vats, each containing 3 liters of skim milk, in a large vat for uniformity of heating. The 4 lots of cheese were made simultaneously according to the short-time method and the only difference in the procedures was the use of different concentrations of iodine in the wash water, i.e. 0.0 (control), 2.5, 5.0 and 12.5 ppm. The skim milk starter and coagulator were obtained from a local dairy plant.

Iodine concentrations were determined using the selective iodine ion electrode with a single and double junction reference electrode on an Orion 901 Microprocessor Ionalyzer. Raw milk samples were weighed (102 g) into 250 ml beakers and the ionic strength was adjusted by the addition of 2 ml 5 M $NaNO_3$. Equilibrium was reached after 3 minutes of stirring at which point iodine levels were read using the direct measurement method as outlined in the Orion instruction manual. Cottage cheese was analyzed in the same manner with the exception that the samples were first diluted and blended with twice the volume of 2% sodium citrate.

RESULTS AND DISCUSSION

Of the 359 samples examined, 290 were from fluid and 69 from industrial milk shippers. Interestingly, the average iodine value of all producers for that period of time was 0.929 ppm, with the fluid milks having a higher level (0.990 ppm) than those obtained from the industrial milks (0.677 ppm). The range in milk iodine values of these producers is shown in Table 1. As may be observed, only 54% of the producers provided milk with less than 0.4 ppm and 20% had values exceeding 1.0 ppm. Of the farms producing the highest levels of iodine in the milk, most were large fluid milk producers considered to be the most efficient and well managed. These values could be of concern for they exceed the upper limits of 0.500 ppm as recommended in Switzerland, Austrialia and the United States (Bruhn, 1981).

Since it was difficult to continue analyzing this number of milk samples, 41 shippers were selected for further study. The basis of the selection was to choose shippers who produced milk ranging from high levels of iodine (>1.0 ppm) to those with low amounts (<0.2 ppm). The summary of the data collected during this nine-month trial is shown in Table 1 with specific levels being illustrated in Figure 1. In general it was found that although a slight decline in the average values took place, little variation occurred in herd milk samples collected from individual producers. Those with low levels generally remained low while those with high levels usually remained high. Obviously variations did occur during this test period, but if one remembers the low levels being recorded, these differences should be considered minor. However, even after the nine-month trial a large percentage of the milks still retained abnormally high levels of iodine. It should be pointed out that during this period no attempt was made to influence the producers in regard to their milking practices. The only objective was to record iodine levels and where possible to determine usage of iodine compounds on farms. Farm

[1] Udder San. West Agro 1.75% iodine
[2] Bovadine West Agro. 1.000% iodine

visitations confirmed that many of the milks containing excessive levels of iodine included those from the large fluid milk producers who did not use any iodine type of sanitizer, udderwash, teat dip or other compounds in their operation, but included ample qantities of mineral supplements in the cow's diet. Further, the inspection of farms revealed that several samples of the low iodine milks were obtained from producers utilizing iodine products in their milking practices. While time did not permit analyses of feed for iodine content, this preliminary information indicates that feeds, and in particular iodine supplemented feeds, are of far greater concern than farm iodine compounds as contributors to high levels in milk.

Since iodine containing udder washes and teat dips have been suggested as contributors to iodine content of milk (Dunsmore, 1977), two trials were carried out with the University herd to determine whether these compounds may contribute to increased levels of iodine (Figure 2). In the first trial the results appear to suggest that these compounds did exert an influence on iodine levels of milk. However, careful examination of the data in Table 2 which includes mean and standard deviation values shows that the increases observed in all cows but one (No. 254) could not be considered as significant. The increase noted in cow No. 254 is difficult to explain although this cow characteristically exhibited wide daily fluctuations in iodine values. The unusually large increase observed in the post treatment phase in this animal apparently was associated with an incidence of the animal being treated for bloat.

In the second trial all conditions were similar with the exception that greater care was taken to ensure similarity in feeds for all animals. In this instance, the iodine udder wash and teat dip had no influence on iodine levels of the milk samples. If anything, lower levels were obtained during the treatment period. This was particularly true for cow No. 254 whose significant decrease during the treatment period was opposite to the results obtained in the first trial. The fact that the iodine treatments described in these trials had little to no effect on iodine levels in milk, appears to be contrary to work carried out by Dunsmore in Australia (1977). However, these data do support studies by Hemken (1981), and Cantor and Most (1976) who reported only minor increases in milk levels providing these compounds are used properly.

Iodine levels of individual cows' milk are subject to variations. Two typical sets of data were selected representing daily iodine levels of two cows over a thirty day period, one with wide fluctuations in values (No. 214) and the other exhibiting only minor changes during the same period of time (No. 221). This simply indicates that iodine levels in individual cows do change, with variations in some milks being more evident than others.

The information gathered in this study indicates that iodine values of some raw milk supplies in the Saskatoon milk shed exceed normal levels.

This situation is not unusual, for a review by Hemken et al. (1981) reported results from several studies in which iodine values of farm milk ranged from less than 0.1 to greater than 4.0 ppm. Of particular interest, was a five year program carried out in California which reduced mean iodine levels from an average of 568 to 256 ppm (Bruhn et al., 1983). This was accomplished through care in the use of iodine for treatment of animals, sanitizing agents and the monitoring of feed supplies. It appears evident that iodine levels in a number of herds' milk examined in this study should be reduced. While Hanson (1981) has suggested that iodine levels of raw milk should not exceed 100 to 150 ppm, conclusions from other studies indicate that a more realistic approach would be to maintain a level at least below 500 ppm. Perhaps a better goal would be to obtain a level similar to that which was accomplished in California.

Iodine-containing compounds also are commonly used in dairy processing plants as sanitizing agents. Usually the large volume of milk product passing over proccessing equipment in relation to the small amount of sanitizer used, is such that very little increase in milk or milk product iodine levels is expected. One product, however, which could be affected is cottage cheese. In this process the cheese curd is cut into small cubes cooked and separated from the whey by draining through a screen. The common practice is to then wash the cubes with water three separate times with draining after each application, in order to cool and to firm the curd. Since some bacteria do exist in most water supplies, a small amount of sanitizer is added to prevent contamination of the cheese. While greatly beneficial to the extension of product shelf-life, this practice also provides excellent conditions for the possible absorption of a sanitizer to the cheese.

Consequently, two series of trials one under commercial conditions and one in the laboratory, were conducted to determine whether iodine added to wash water is absorbed by the cottage cheese curd. In the first trial (Table 3), iodine levels of curd and whey were recorded at various stages during the manufacture of this product in a local dairy plant. A total of six commercial vats of cheese were analyzed during this study and the data presented in this table show the results obtained from two typical vats. As may be noted some increase in iodine content of curd is apparent in both runs. However, it should be realized that the iodine level of the dry curd cottage cheese in vat No. 1 was still lower than that found in the original skim milk. Most of the iodine found either in the skim milk or added with the wash water was not absorbed onto the cheese but rather was removed with the wash water. Analyses of the second vat show similar findings although slightly higher iodine values were observed in the cottage cheese than in the skim milk. Results obtained from these two vats represent average values with the other runs showing either slightly lower or slightly higher levels in the final cheese products.

To better understand whether interactions between iodine and curd do occur, a second trial was carried out whereby cottage cheese was produced under controlled laboratory conditons. In this phase of the study, wash water ranging from 0 to 12.5 ppm iodine was used in the manufacturing process (Table 4). In the control vat, in which no iodine was used, washing of the cheese curd resulted in a gradual lowering of iodine suggesting that iodine in milk is found primarily in the serum or water soluble phase. In general, the use of iodine in the wash waters resulted in increased levels in the curd, the amount directly corresponding to that found in the water. The increase observed in the 2.5 ppm treatment was modest with most of the added iodine being lost in the discarded whey. Marked increases were found in the curd treated with higher levels of iodine such as 1.63 and 4.46 ppm with water containing 5.0 and 12.5 ppm, respectively.

These results suggest that if small quantities of iodine are used in the washing steps, at recommended levels, little increase in amounts of curd iodine is apparent. However, if abnormally high levels are used in the wash water, undesirably high levels may be found in the cottage cheese. Further, only a small proportion of iodine appears to be associated with the protein fraction, which is the major component of cheese. This observation agrees with the results of Wheeler et al. (1983) who reported that the bulk of milk iodine, whether pysiological or iodophor-derived, was associated with the water soluble whey portion. It does appear that washing cheese curd with untreated water does lower curd iodine values. However, experience has shown that the use of untreated wash water will adversely affect the shelf life.

IMPACT

A survey of raw milk in the Saskatoon milk shed indicated that several herds had abnormally high levels of iodine in their milk supplies. Iodine-containing sanitizers, teat dips, and udder washes, when used at recommended levels, appeared to exert little effect on amounts of milk. Feed supplies, in particular those supplemented with iodine seemed to be primarily responsible for the increased concentrations detected in these milks. Steps should now be taken to reduce the high iodine levels in raw milk by monitoring feed supplies and by providing information on factors affecting iodine concentrations. During the manufacture of cottage cheese, the use of iodine in wash water resulted in increased concentrations in the curd, ranging from modest at recommended treatment levels to marked at abnormally high levels of supplementation.

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Table 1. Distribution of farms according to milk iodine content.

Range in iodine content (ppm)	All Producers[1]		Monthly samples of selected shippers									
			May		July		Aug		Sept		Oct	
	No	%	No	%	No	%	No	%	No	%	No	%
<0.200	81	22.5	7	17.0	13	17.5	13	16.2	15	18.2	4	5.8
0.2-0.399	114	31.7	4	9.8	20	27.0	17	21.2	10	12.1	18	26.4
0.4-0.599	47	13.0	4	9.7	10	13.5	11	13.7	8	9.7	9	13.2
0.6-0.799	30	8.3	6	14.6	4	54.0	9	11.2	15	18.2	6	8.8
0.8-1.000	15	4.1	6	14.6	3	4.0	3	3.7	8	9.7	7	10.2
>1.000	72	20.0	14	34.1	24	32.4	27	33.7	26	31.7	24	35.2
Total	359		41		74		80		82		68	

Range in iodine content (ppm)	Monthly sampels of selected shippers									
	Nov		Dec		Jan		Feb		Mar	
	No	%	No	%	No	%	No	%	No	%
<0.200	14	17.9	19	25.3	8	10.6	14	18.1	5	13.5
0.2-0.399	16	20.5	12	16.0	16	21.3	11	14.2	6	16.2
0.4-0.599	19	24.3	15	20.0	16	21.3	18	23.3	8	21.6
0.6-0.799	10	12.8	12	16.0	8	10.6	12	15.5	7	18.9
0.8-1.000	3	3.8	5	6.6	11	14.6	4	5.1	1	2.7
>1.000	16	20.5	12	16.0	16	21.3	18	23.3	10	27.0
Total	78		75		75		77			

1 - Saskatoon milk producers survey, May - June, 1982

Table 2. Effect of udder wash and teat dip treatments on iodine levels in milk (ppm) of randomly selected cows in the University of Saskatchewan herd.

Cow No.	Pretreatment $\bar{X}$	Pretreatment S.D.	Treatment $\bar{X}$	Treatment S.D.	Post treatment $\bar{X}$	Post treatment S.D.
			Trial 1			
184	0.173	0.122	0.255	0.097	0.328	0.052
214	0.252	0.093	0.216	0.037	0.277	0.043
254	0.276	0.108	0.526	0.190	0.593	0.131
261	0.160	0.041	0.230	0.076	0.246	0.038
264	0.260	0.094	0.343	0.131	0.928	0.577
280	0.101	0.036	0.163	0.072	0.204	0.085
284	0.229	0.060	0.255	0.130	0.234	0.066
			Trial 2			
206	0.272	0.081	0.205	0.020	0.132	0.030
214	0.338	0.140	0.221	0.026	0.157	0.056
254	0.631	0.358	0.293	0.060	0.191	0.033
221	0.127	0.016	0.142	0.025	0.107	0.033
233	0.129	0.037	0.146	0.025	0.112	0.030
243	0.216	0.040	0.153	0.030	0.137	0.032
294	0.140	0.033	0.151	0.051	0.104	0.031

Table 3. Iodine contents of curd and whey (ppm) during the manufacture of two vats of cottage cheese under commercial conditions.

Stages of manufacture	Vat No. 1		Vat No. 2	
	curd	whey	curd	whey
Skim milk	0.602		0.660	
After first washing	0.339	0.397	0.360	0.243
After second washing	0.779	1.325	0.721	0.986
After third washing	0.533	1.030	0.732	0.406
Dry Curd	0.524	---	0.733	---

Table 4. Effect of iodine-containing wash waters on iodine content (ppm) of whey and curd during manufacture of cottage cheese.

Stages of manufacture	Wash water (ppm) 0.0		2.5		5.0		12.5	
	curd	whey	curd	whey	curd	whey	curd	whey
Unwashed	0.245	0.510	0.223	0.500	0.235	0.602	0.271	0.534
After first washing	0.130	0.181	0.282	1.050	1.310	4.130	2.270	9.590
After second washing	0.083	0.046	0.327	1.170	1.530	4.075	3.350	9.645
After third washing	0.071	0.024	0.495	1.205	1.630	3.510	4.460	8.095

1 - Iodine content of skim milk - 0.496 ppm.
2 - Curd and whey immediately after cooking and draining steps.

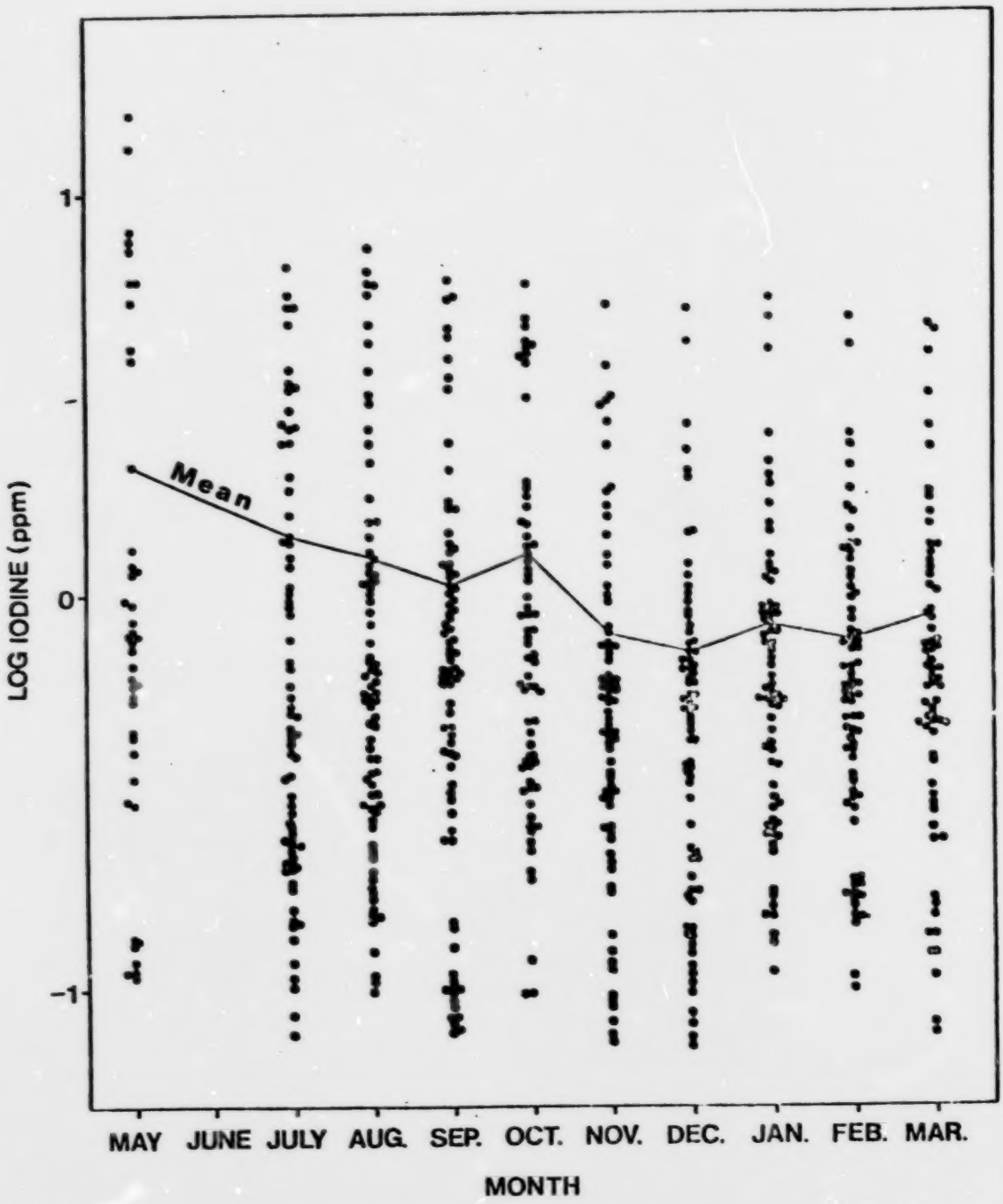

FIGURE 1. Distribution of milk iodine values of selected shippers in the Saskatoon milk shed from May 1982 to March 1983.

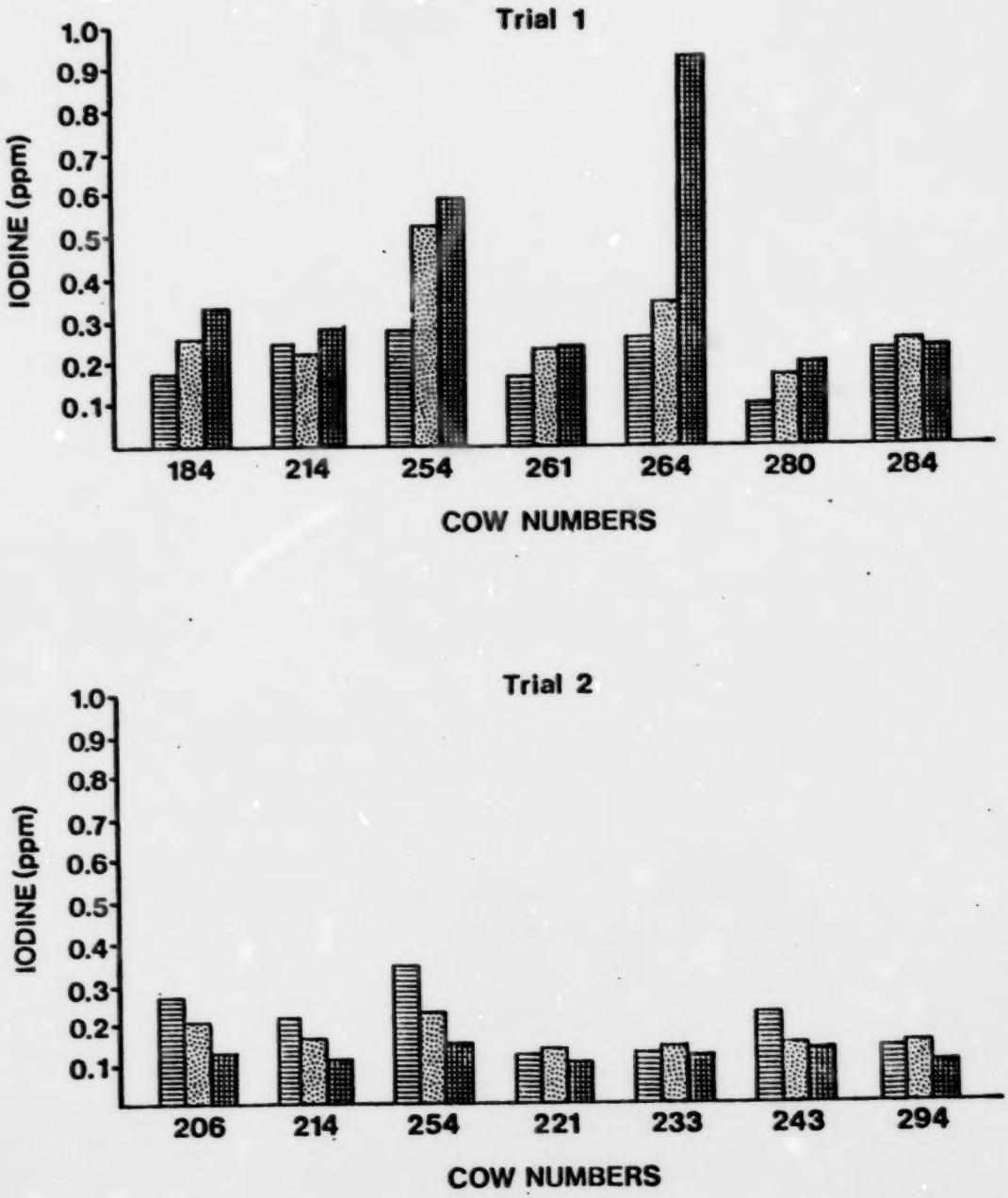

Figure 2. Effect of udder wash and teat dip treatments on iodine levels in milk from randomly selected cows in the University of Saskatchewan herd: ▤ pretreatment, ▨ treatment, ▩ post treatment periods.

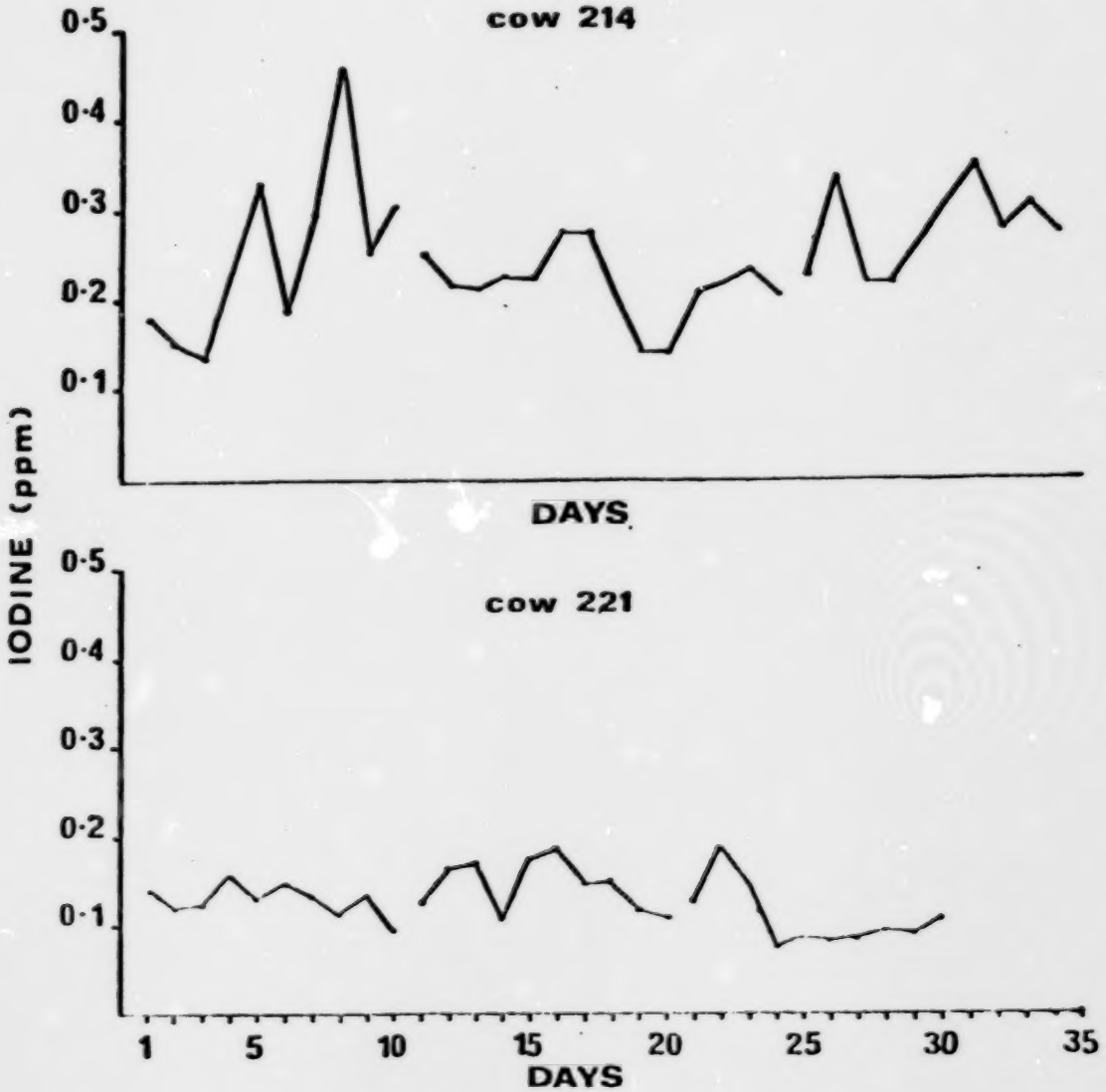

FIGURE 3. Daily variations of iodine content of two selected cows from the University of Saskatchewan herd.